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SOUTH WALES

A PHYSICAL AND ECONOMIC GEOGRAPHY

BY

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WITH THIRTY-FOUR MAPS AND DIAGRAMS

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PREFACE

THE present work deals with the South Wales Coal-field and with the rural and industrial areas immediately adjacent to it. The authors have chosen to eat of this region rather than of Wales as a whole, because, ce the Industrial Revolution, Wales has lost much of the ity it may formerly have possessed. South Wales, how-er, may be considered as forming a geographical unit, the undaries of which the authors do not propose to define ecisely, for such a unit does not necessarily have a definite undary. Thus in the Middle Ages the coastal lowlands South Wales were, in the main, quite distinct from the al-field area, which might then have been considered as more than an extension of the barren plateau of Central ales. With the utilization of iron-ore and coal, the coal-ld became of greater importance, and in a way detached elf from the plateau to the north, while subsequently, as dustrialization proceeded, the areas near the coal-field were fluenced to an increasing extent. This book therefore als chiefly with the counties of Glamorgan, Monmouthshire d Pembrokeshire, and with parts of the counties of Car-arthenshire and Breconshire, but no attempt has been made give a uniform treatment to all parts of those counties.

The authors have attempted to give only a general outline the more important factors which have determined the ography evolution of the area, and much detail has cessarily been omitted, but it is hoped that the facts which e given are sufficiently illustrative, and that those readers no are acquainted with particular areas will fill in the more mplete story (perhaps qualifying, in some degree, the more neral conclusions reached here, which apply to the region a whole). The present work represents perhaps the first tempt at such an account of South Wales, and it can scarcely e hoped that it will be entirely free from errors, for much rther research is needed on certain of the problems dealt ith. It is hoped that the following chapters will stimulate quiry: indeed, this book may be considered to have achieved useful end if the reader finds that as many new questions e raised as are answered.

The order of the chapters probably requires some explanation. An unusual feature of the book is the moderately long account of the geology and physical features. In every region the geological structure has influenced the development and conditioned human settlement, but probably in no part of Britain have man's activities been so controlled at every step by geological factors, as they have in South Wales. In the opinion of the authors a knowledge of these factors is essential to an understanding of South Wales; mere description of the structure without any appreciation of its origin or of its relation to a time-scale appears to be both dull and uninforming. The geology is treated simply, and it is hoped that readers with no previous knowledge of the subject will be able to follow the chapters without difficulty; a glossary of certain technical terms is included in the book.

Subsequent chapters, especially those dealing with the copper, iron and coal trades, are arranged approximately in a historical sequence, the industries dealt with first being those which were the earliest to develop. But it must be pointed out that the whole story of the area is essentially one, and that in their development all the industries are closely inter-related. The difficulty which results from the treatment of various industries in separate chapters is to some extent overcome in the later chapters, where the transport and population problems of the whole area are discussed.

The diagram maps which are given in illustration, especially those showing the geology and physical features, are intended to assist the reader to gain a general impression of the main features, but the more serious student is advised to consult maps of the area on a larger scale, details of which are given on page 179.

In the preparation of this work the authors have received much assistance from many friends and colleagues. In particular, valuable information and advice have been given by Mr. David Brunt (of the Meteorological Office), Mr. W. Morgan James (of the Great Western Railway, Swansea), Mr. Lewis Jones (of the South Wales Siemens Steel Association), Mr. T. G. Williams (Clerk to the Urban District Council, Milford Haven), and Mr. T. R. Ronald (of the Consolidated Fisheries, Swansea). Principal C. A. Edwards and Professor E. Ernest Hughes have each read some portion of the manuscript and made helpful suggestions.

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SOUTH WALES

CHAPTER I

THE BUILDING OF SOUTH WALES

TO appreciate fully the geography of South Wales—or for that matter, of any area—it is necessary to study its growth from earliest times. Every phase f its history has influenced its development and has left its race on present-day distributions. This is true, for instance, f the human settlements in the area, the sites of some of ne towns having been determined hundreds of years ago y factors which are no longer of much importance. In the resent chapter it is proposed to deal with the very earliest nfluences, most of them dating from times long before South Vales was inhabited by man. The changes which took lace hundreds of millions of years ago, before Britain had nything of its present form, are often of great importance in etermining the scenery of the country, the fertility of the oil, and the distribution of the minerals.

Through the long ages which have elapsed since the earth rst came into being, perhaps more than a thousand million ears ago, many forces have been at work moulding the form f the land. During its long history the area which is now outh Wales has undergone great changes, and for several ong periods has been submerged below seas in which most f the rocks forming the present land have been made. Between these periods of rock formation, this part of Europe vas raised above sea-level, and portions of the newly formed ock masses were worn away by the action of rain, rivers, nd other denuding agents.

1

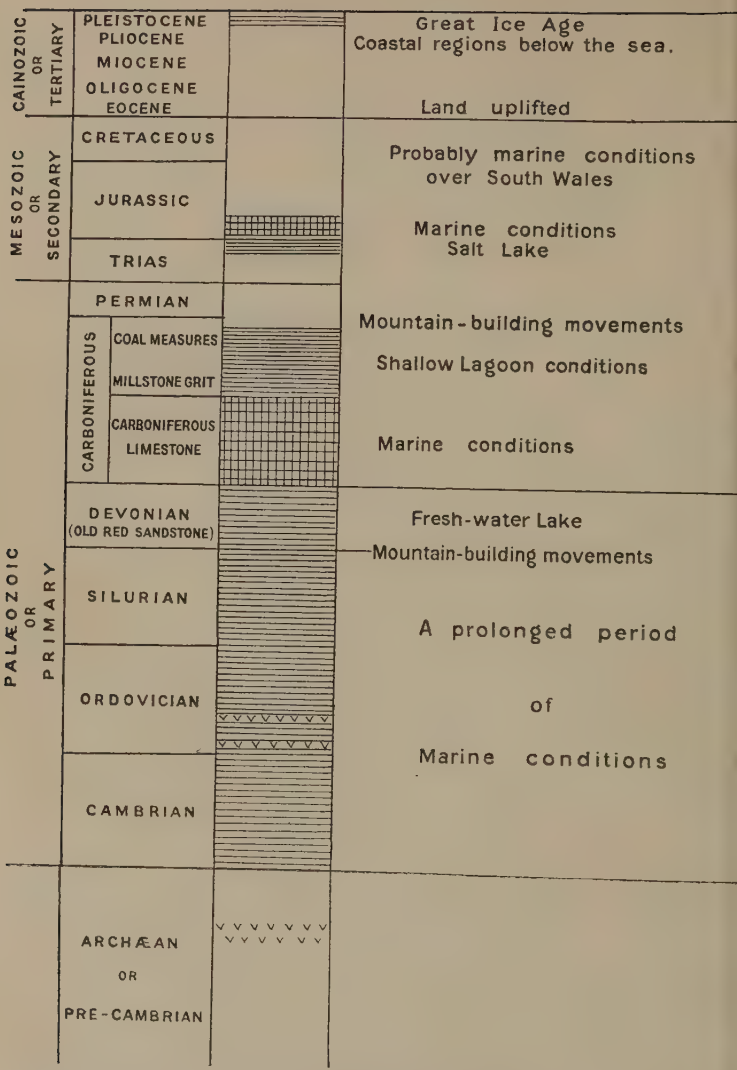


FIG. 1.—A Geological Time Scale

The thickness accorded to each group is roughly proportional to the length of the period, except that the Tertiary is probably too long and the Pre-Cambrian too short. The shaded parts of the centre column correspond to those periods which are represented by rocks in South Wales; in this shading the squares indicate limestones, the horizontal lines sandstones, clays, etc., and the v's volcanic rocks.

The various ages in the history of the earth are shown in fig. 1, which illustrates approximately the proportional lengths of the periods. The grouping of these periods by the geologist has been based on the fossils contained in the rocks; in each period during the history of the earth the animals and plants have been different from those of the present time. It is sufficient to understand that the basis of historical geology is the progression of life, and it is not necessary for us to follow in detail the methods used by the geologist for the classification of the rocks.

The shading in the centre column of fig. 1 indicates those ages which are represented by rocks in South Wales. The rocks occurring at the surface of the ground in different parts of South Wales are of different ages, and a geological map of the area shows the distribution of the rock groups at the surface (fig. 2). The most widespread rocks in South Wales are those of Carboniferous age, the Coal Measures occurring in the coal-field and the Millstone Grit, Carboniferous Limestone and Old Red Sandstone on its northern and southern margins. Further north again, Lower Palæozoic rocks occur (Cambrian, Ordovician and Silurian).

The South Wales coal-field and the area to the north of it form a plateau region (the eastern part of which is known as Blaenau Morganwg) rising in the north to 2,000 feet above sea-level, and sloping southwards to heights ranging from 600 to 1,000 feet above sea-level near the southern margin of the coal-field, except in the extreme west, where the land is not so elevated. To the south of the coal-field are three coastal areas, namely, from east to west, the Vale of Glamorgan (Bro Morganwg), the Gower Peninsula, and south Pembrokeshire, cut off from one another by Swansea Bay and Carmarthen Bay respectively. These three areas are plateaux at a lower level than that of the coal-field area to the north, rising generally to a height of 200 to 400 feet above sea-level. In both south Pembrokeshire and Gower, the plateaux consist mainly of Carboniferous Limestone, while in the 'Vale' the same rocks are present but are partly concealed by a covering of rocks of the Triassic and Liassic (Lower Jurassic) ages.

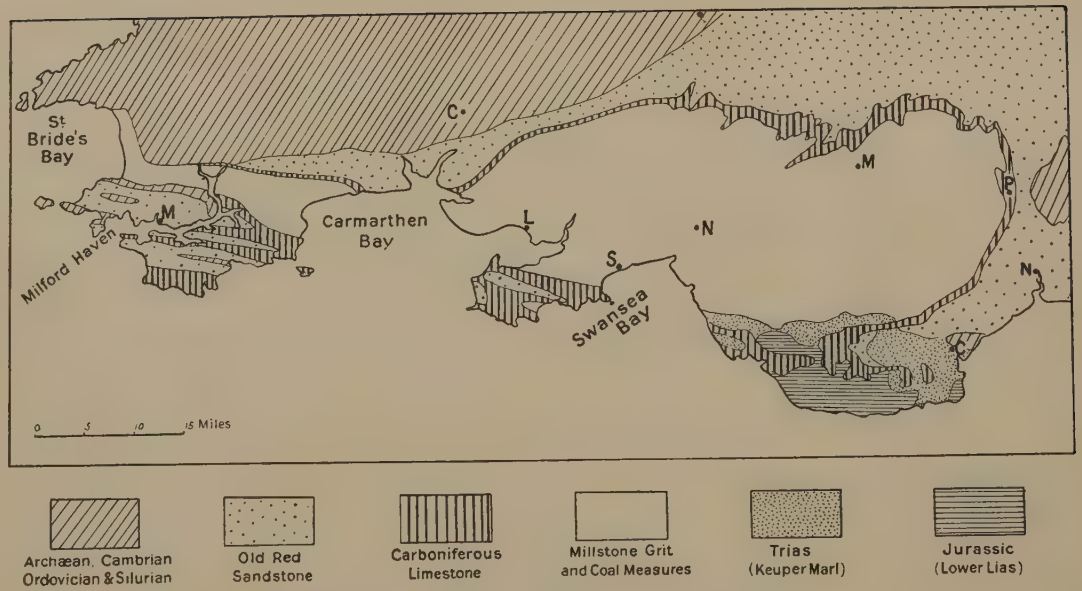


FIG. 2.—A Geological Map of South Wales

The Older Rocks of South Wales

The oldest rocks in South Wales are of Archæan or Pre-Cambrian age, and are best seen near St. Davids in Pembrokeshire, although they also occur in several other small areas in the same county. At St. Davids, the Pre-Cambrian rocks consist mainly of ashes thrown out by volcanoes and laid down under water. As is the case with Archæan rocks generally, they contain no fossils. The area occupied by these rocks at St. Davids is only about seven miles long and two miles broad, but from that area the rocks extend downwards under the Cambrian rocks and their underground extent is much greater. Indeed Archæan rocks must occur, though often at very great depths, under every part of South Wales. These ancient rocks are exposed at the surface near St. Davids because the Cambrian and later rocks which formerly extended over them have been removed by denudation. The removal of so great a thickness of rocks was due to the fact that they were bent upwards in a great upfold or anticline ;[1] the more ancient rocks are now exposed in the core of this structure.

The succeeding Cambrian, Ordovician and Silurian rocks are the most characteristic rocks of Wales as a whole. In fact, in Wales they are most typically developed, and the study of the Lower Palæozoic rocks began in this country, from which they take their names. The Cambrian, Ordovician and Silurian rocks consist mainly of consolidated muds, which have often been converted by intense pressure into slates. In some parts these rocks include beds of sandstone or grit, and in the Ordovician and Silurian are occasional beds of limestone. The Lower Palæozoic rocks were laid down in a sea which extended right across Wales and into Scotland ; land existed to the south, and at some stages the coast-line actually passed through South Wales. In those times there was practically no life on the land, either animal or vegetable, while in the seas there lived only strange invertebrates, the first fishes not making their appearance until almost the close of Silurian times.

[1] This and other terms are defined in a glossary, page 171.

During the greater part of Ordovician times there were numerous outbursts of volcanic activity, lava and ashes being spread over the sea floor. In Wales the most important traces of volcanic activity are found in the mountains of North Wales, notably in Cader Idris and Snowdon, where the tough beds of igneous rock have withstood denuding agencies more successfully than the slates and grits of the surrounding regions.

The greater portion of central Wales is built up by a series of grey slates and sandstones of late Ordovician and Silurian age, which give rise to a dissected plateau, of rather monotonous aspect. The Cambrian and the early Ordovician rocks are not exposed at the surface over much of the area between Merionethshire and Pembrokeshire, but in the east there are upfolds or anticlines sufficiently sharp to bring the Ordovician volcanic rocks to the surface, giving rise to the more diversified country of the 'Wells' as at Llanwrtyd, Builth and Llandrindod.

In South Wales the Lower Palæozoic rocks occupy a wide area in north Pembrokeshire and Carmarthenshire (fig. 2). They consist mainly of shales, sometimes converted by pressure into slates, with some sandstones, flagstones and thin limestones. South of this area they extend under newer rocks, only being seen at the surface where the newer rocks have been removed in regions of anticlinal folding, as at Usk (Mon.), Penylan (Cardiff), Cefn-y-Bryn (Gower), and in some small patches in south Pembrokeshire. In South Wales the Ordovician rocks contain far less volcanic material than in North Wales, and consequently the rough scenery of North Wales is not reproduced, but lavas are found in several parts, as in Skomer Island and on the adjoining mainland at Marloes Bay in south-west Pembrokeshire, and at Trefgarn Bridge, north of Haverfordwest.

While these Lower Palæozoic rocks were being deposited the crust of the earth where the deposits accumulated must have continually sagged downwards, otherwise the sea would have been silted up and probably deposition would have ceased. But immediately after this very prolonged period of relatively uninterrupted subsidence and deposition there came a re-

ction, the Lower Palæozoic sediments being thrown upwards nd compressed by lateral pressures so as to form a range f mountains, the dominant structures of which ranged enerally from north-east to south-west. These structure nes are still to be recognized in many parts of Britain where he Lower Palæozoic rocks are found, although the great nountains of which they are but the roots have long since isappeared. In Wales a series of such folds may be recog-ized in Anglesey and parts of North Wales, while further outh two main lines of anticlinal folding trending north-ast to south-west may be recognized along the lines of the Teifi and Towy valleys, between which is a complex syncline, he Central Wales Syncline. Of these structures, the Towy Anticline is the only one which enters into the area dealt with n the present volume.

The Old Red Sandstone

Mainly as a result of these earth-movements the geography of the area underwent a complete change at the beginning of Devonian times. From that time, the major part of North and Central Wales became land which was not com-pletely submerged for a long period. On the other hand, South Britain lay beneath the Devonian sea, and marine sediments accumulated in Devonshire. In south-east Wales, occupying the area now covered by Breconshire, Glamorgan, Monmouthshire, Herefordshire and Gloucestershire, as well as the south of Carmarthenshire and Pembrokeshire, was an area in which red rocks were laid down. These were probably not laid down under marine conditions, for they contain none of the marine invertebrates, such as corals, which are found in the Devonian rocks of Devonshire, and it is generally considered that they were deposited either in a freshwater lake or in an almost land-locked arm of the sea. These red rocks are thus of Devonian age, but they are so different in character from the marine strata of that period that they are usually referred to under the name of 'Old Red Sandstone'.

The Old Red Sandstone rocks in South Wales are generally reddish or brown in colour, but they are not always sandstone.

The following divisions are recognized in the Brecon Beacons, where the rocks are thicker than elsewhere in South Wales :

Grey Grits (at the top).
Plateau Beds,—coarse conglomerate with quartz pebbles.
Brownstones,—brown sandstones.
Senni Beds,—olive green sandstones.
Red Marls, with thin sandstones, and beds of ' cornstone '.

The lower part of the Old Red Sandstone consists of soft red marls (calcareous clays) with thin bands of sandstone and beds of compact limestone known as ' cornstones ', from the nature of the soil to which they give rise. The succeeding beds are coarser and more sandy, while the Brownstones are followed by an extremely tough quartz conglomerate. As would be expected, these rocks are comparatively devoid of fossils but they contain rare traces of fishes and of lowly plants.

The Carboniferous Rocks

With the succeeding Carboniferous period, further subsidence allowed the sea to advance northwards, the ' Welsh Lake ' being converted into an extension of the sea, but still with land to the north, in Central Wales and in north Pembrokeshire. The Carboniferous rocks may be grouped as follows :

Coal Measures	Upper Coal Series Pennant Sandstone Series Lower Coal Series
Millstone Grit	
Carboniferous Limestone	Upper Limestone Shales Main Limestone Lower Limestone Shales

The lowest division, the Carboniferous Limestone or Mountain Limestone, was deposited over approximately the same area in South Wales as that covered by the Old Red Sandstone. The Limestone is a typical marine deposit, generally greyish in colour and occurring for the main part in thick beds of massive limestone, rich in fossil corals and

e shells of Brachiopods. The upper and lower parts of the rboniferous Limestone, known as the Upper and Lower mestone Shales, consist of thin limestones interbedded th shales, but the Main Limestone makes up fully three-arters of the total thickness. In South Wales, the Carboni-rous Limestone is thickest and best seen in the Gower ninsula and in south Pembrokeshire, where it is about 4,000 et thick and is similar in its development to the Carboni-rous Limestone in the Mendips and near Bristol. In other rts of South Wales, as for instance near Haverfordwest, d from Kidwelly through Llandebie to Abergavenny, on e north of the coal-field, the Limestone is much thinner.

The succeeding Millstone Grit Series represents a change the conditions ; during the deposition of the Carboniferous mestone very little sediment had been carried from the nd into the sea, the Limestone being built up largely from e remains of organisms, while the rocks of the Millstone rit and Coal Measures are made up almost wholly of muddy d sandy sediments carried by rivers from the land. The illstone Grit of South Wales is rarely to be closely compared its characters with the rocks bearing the same name in orkshire, for it is often represented rather by shales than grit and sandstones. In Fforest Fawr (or the Black ountains) of Carmarthenshire, the Millstone Grit is more sistant than elsewhere in South Wales since it consists to large extent of sandy materials ; the sandy beds are gener-y fine quartzites and quartz conglomerates. Southwards, stwards and westwards from this area the Millstone Grit nsists of shales with thinner grit bands, and does not give e to such elevated country.

In general characters the Coal Measures are very similar the Millstone Grit, and there is no sharp line of demar-tion between them. It may be noted that the Millstone it contains no coal seams of economic value, but neverthe-s some thin seams are found in many areas. The Coal easures consist essentially of a series of sandstones and ales laid down in shallow water and, at least partly, in sh water. Interbedded with these strata are seams of al, not making up more than a small fraction of the total

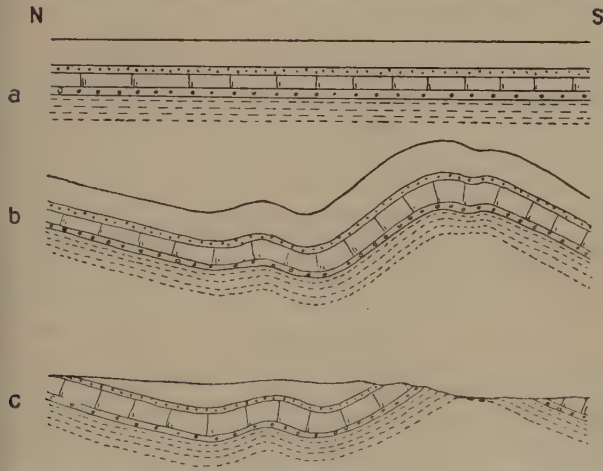
thickness. Each coal seam is made up of the remains of the vegetation of the period which had become much more highly developed than that of Old Red Sandstone times. Tall trees, ferns and strange plants, of types quite different from any which are found in our forests to-day, and including no flowering plants or trees, probably grew from time to time over the whole area which is at present the coal-field, the soil in which they grew being found as a 'seat-earth' or fireclay beneath practically every seam. Among the shales in many places are layers of ironstone nodules, generally consisting of isolated nodules, sometimes irregular, but frequently in the form of flattened spheres.

The Coal Measures of South Wales are divided into three groups which are most clearly distinguished in the eastern end of the coal-field. The upper and lower groups, called respectively the Upper Coal Series and the Lower Coal Series, are similar in character, and consist mainly of shales with few sandstones and with many coal seams and ironstone beds. These divisions are separated by the Pennant Sandstone Series, which consists of dull grey sandstones containing scarcely any workable coals. In the west of the coal-field these three divisions are not so well marked ; a group of sandstones similar in character to the Pennant Sandstones and called the Llynfi Rock occurs in the upper part of the Lower Coal Series, while the upper part of the Pennant Series is less sandy than in the eastern area and contains a number of important coal seams.

The Structure of the Coal-field

The present distribution of the Carboniferous rocks and the structure of the coal-field were largely determined at the end of Carboniferous times. The period of deposition, which had lasted with slight interruptions from the beginning of the Devonian to the end of Carboniferous times, was brought to an end by another series of earth-movements. Chiefly as a result of pressures from the south, the Old Red Sandstone and Carboniferous deposits were thrown up into a number of folds, anticlines and synclines, trending approximately east and west (fig. 3, *b*). These folds were produced by mountain-

uilding movements which affected an extensive tract from e south of Britain to the Continent, and which are generally nown as the Armorican movements. South Wales was on e northern flank of this belt of folding, and in general the mpression was less intense than in Devonshire and Corn-all. In south-east Wales in particular, the folds produced ere rather wide and shallow, but steeper on the south where e pressure was greater than on the north. In south-west



G. 3. –Diagrams to illustrate the Origin of the South Wales Coal Basin

shows the Old Red Sandstone, Carboniferous Limestone, Millstone Grit and Coal Measures d down in horizontal beds; (*b*) the same rocks after the Armorican folding; and (*c*) after udation (early in the Trias), with the Coal Measures preserved in the syncline on the north but completely removed from the anticline on the south.

Vales the folding was more intense, for the Upper Palæozoic ocks were there pressed against the resistant mass of Lower alæozoic sediments which had already been compressed in he Devonian earth-movements, and which resisted further ovement. Accordingly, the Carboniferous rocks are more harply folded in Pembrokeshire than in Monmouthshire; hus the folds are frequently broken, allowing detached asses of the rocks to be thrust towards the north, and in me places for instance the Millstone Grit has been forced ver an area of Coal Measures.

The chief result of the compression in the South Wales region was to produce an elongated basin or syncline on the north, and a series of anticlines or upfolds on the south (fig. 3, *b*). Probably in places the tops of the anticlines were more than 12,000 feet higher than the highest parts of the synclines. Therefore the anticlinal regions were exposed to vigorous erosion and became worn down much more rapidly than the area within the synclines. Consequently, the Coal Measures, which of course formed the uppermost layer over all the folds, and much of the Millstone Grit, were removed from the anticlinal areas; in some places the whole of the Carboniferous Limestone and Old Red Sandstone were also removed, exposing the more ancient Lower Palæozoic rocks in the cores of the sharpest anticlines (fig. 3, *c*). On the other hand, only a portion of the Coal Measures was worn away in the synclinal area; the Upper Coal Series, being the uppermost group, suffered to a greater extent than any other division and was worn away from all but the deepest parts of the basin (fig. 4).

Thus at this early date the general form of the coal-field was determined by folding and the subsequent denudation, and

FIG. 4.—A Section from North to South across the Eastern Part of the South Wales Coal-field, from near Merthyr to near Cardiff. (The section is somewhat generalized and does not follow exactly any particular line.)

1, Old Red Sandstone (*a*, mainly marls; *b*, sandstone and conglomerate); 2, Carboniferous Limestone; 3, Millstone Grit; 4, Coal Measures (*a*, Lower Coal Series; *b*, Pennant Sandstones; *c*, Upper Coal Series); 5, Trias.

e wider areas of Coal Measures, which almost certainly re formerly in existence outside the limits of the present al-field, were completely removed.

The syncline which now coincides in extent with the South ales coal-field, is not a simple structure. Within it, as ght be expected, are other minor folds, appearing more or s as ripples within the big basin, but all trending approxi-tely east and west, and all due to the same general cause g. 4). These folds are broken at regular intervals of a le or so by faults or fractures which run approximately m north to south, thus crossing the folds more or less at ht angles. At some stage in its subsequent history the al-field has also been fractured and compressed along veral other narrow belts, which extend from north-east to uth-west ; the valleys of the Neath and Tawe coincide in rection with two such belts. It is probable that these last-med fractures originated long after Carboniferous times, and has been suggested that they represent movements during rtiary times (probably Miocene), but there is at present tle positive evidence from which the date can be deduced.

The Mesozoic Rocks

After the period of mountain building at the close of rboniferous time, South Wales was an elevated tract posed to denudation, and no further deposits accumulated ere, for some time. As a consequence of the Carboniferous rth-movements, the areas in Britain which received deposits ring Permian and the early part of Triassic times were ry limited. During these periods, however, much of uth Wales was undergoing active denudation. Not only re the anticlines worn away rapidly, but the anticlinal area the south of the coal-field was actually worn down to a ver level than the syncline (fig. 3, *c*) owing to the structural akness of an anticline, in which the joints in the rocks tend re or less to be pulled open. Therefore, when continual nudation and subsidence of the area once more allowed rt of South Wales to become submerged, it was the area the south of the coal-field which first became invaded by Triassic waters (fig. 4).

The upper part of the Trias, which is represented in South Wales, is known as the Keuper Marl. It consists normally of red marl, sometimes with green bands and with thin beds of sandstone. It represents a deposit laid down in an inland sea, and contains few traces of life. The lake was salt, and in Cheshire and Worcestershire the Keuper Marl includes deposits of rock-salt precipitated during the evaporation of the waters of the lake. In South Wales, however, this stage was not reached, although gypsum (calcium sulphate) was precipitated there and occurs in layers in the Keuper Marl. The Marl is found best in the Vale of Glamorgan, from Penarth to Bridgend. To the west of that area it was laid down near the shores of the salt lake, or near islands in the lake, and hence it is of 'littoral' character, containing pebbles derived from the rocks which formed the shore. The small areas of Trias that are found further west in Gower and in south Pembrokeshire also consist of littoral deposits.

The red Keuper Marl thus occupies an area in South Wales which lies generally to the south of the coal-field, and only invades the coal-field at a few places along the south-eastern margin (fig. 2). The waters of the inland lake were apparently rich in iron, and solutions bearing iron compounds percolated downwards into the rocks below; where Carboniferous Limestone occurred below the Keuper lake, veins or irregular masses of iron-ore were deposited in the Limestone.

After this period a further subsidence admitted the sea into the area occupied by the Keuper lake. With the first entry of the sea a thin series of shales and limestones, known as the Rhætic, were laid down, to be followed by the Lias, the lowest part of the Jurassic. The Liassic rocks consist of limestones and shales in thin, rapidly alternating layers; they are blueish in colour, and are typical marine deposits. In South Wales they are now found only in the Vale of Glamorgan, from Penarth to near Porthcawl, but it is certain that they had a much wider extent at the time of their formation, and they have subsequently been removed from many areas.

From Liassic times onwards there was probably further subsidence, lasting, apart from certain interruptions, until

ıe end of Cretaceous times. During this period the sea resumably spread further and further over the land, until ossibly the greater part of Wales was submerged beneath ıe sea in which the Chalk was laid down. As the sea en-oached on the land the waves probably planed down its ırface to a fairly smooth plain, until with further subsidence became buried under sediments (see fig. 9, page 31). nfortunately, few records exist in South Wales of this long eriod of deposition, and no Mesozoic rocks newer than the ias have escaped removal.

Tertiary Times

The Jurassic and the Cretaceous rocks (if they were ever eposited) must have been denuded away from Wales during ertiary times. The Cretaceous period was brought to a ose by the recession of the sea (probably resulting from an plift of the land), but this was accompanied by very little sturbance in the way of folding. Since that time, more-er, there has been only slight folding in South Wales, and ence the Lias and Trias deposits are almost horizontal, though they are cut here and there by faults. During the ertiary, however, folding movements occurred in the south-st of England, and at the same time (Miocene) the great ountain chain of the Alps came into existence.

At the beginning of Tertiary times the South Wales region as raised from below the sea. It probably appeared as a ntly inclined plane, sloping perhaps to the south or south-st, and it is generally believed that much of the surface ay have consisted of Chalk, the last deposit of the Cre-ceous. These conditions are illustrated in fig. 9. Rivers gan to flow on this surface, and probably many of the main atures of the present system of rivers were determined at at stage. As the rivers developed they removed the alk, and in most places any other Mesozoic rocks which ay have been present, and thus exposed at the surface the læozoic rocks on which these had been resting, revealing those structures which had been imposed on them by the rious Palæozoic earth-movements.

The main features of the structure of South Wales were

thus determined. During Tertiary times the rivers continued to develop, but there was no other great period of deposition and probably much of Wales was never again depressed beneath the sea. During the Pliocene, however, it is thought that the land stood some 200 to 400 feet lower in relation to the sea than at the present time. As a result, the Pliocene sea spread for some distance over the coastal parts of Wales, and the waves cut platforms at successive stages; these platforms are now elevated above the sea to form the coastal plateaux of south Pembrokeshire, Gower and the Vale of Glamorgan.

Other changes in the relative levels of land and sea are indicated by features which can be observed along the coast. In Gower and south Pembrokeshire there are evidences of an ancient beach, sometimes with shells of marine creatures, at a height of about 25 feet above present sea-level. This raised beach indicates that the land has been uplifted since the time when the beach was formed. On the other hand, on many parts of the coast, more particularly within the bays, there are evidences that the land has been sinking. Such subsidence is more recent in date than the formation of the raised beach, and has been in progress during historical times. As a result of this subsidence, land has been lost, for instance in Swansea Bay, where a submerged forest exists just below high-water mark, with roots and stumps of trees in the position of growth. Moreover, during the construction of docks at many places along the coast, peat beds and other indications of old land surfaces have been met with at depths of as much as 40 feet below the present sea-level, indicating that this movement of subsidence has been of quite considerable extent.

One other episode in the building of South Wales needs to be referred to here. It is probably in the main more recent than the formation of the raised beach, but it is more ancient than the submerged forest, and occurred during the Pleistocene period. This episode, commonly known as the Great Ice Age, was marked by a general lowering of the temperature of the northern hemisphere. As a result, ice-sheets formed, first on the higher ground, and then spread

ross plains and shallow seas. In South Wales, the main centre was in the Brecon Beacons, from which the ice oved generally to the south and east; movement to the st and north was checked by the presence of other ice-eets. In general the Beacons ice moved along the direction the valleys, but at the time when it reached its maximum tent, it stretched over most of the hills. Moving away m the Beacons, the ice overrode the hills immediately to e south, but was then deflected by the higher ground into o main directions, one to the south-east along the valleys the Taff, Cynon, etc., and the other to the south-west along e valleys of the Neath and Tawe. The ice-sheet along the stern valleys reached nearly to Cardiff, while that along the stern valleys reached to the sea. In between was a region, luding the Vale of Glamorgan, which was much less severely ciated.

In the Irish Sea was a great mass of ice, fed by the ice-eets of northern Ireland, south-western Scotland, northern gland and Wales. At its southern border this ice spread twards, perhaps reaching at one stage as far to the east the Vale of Glamorgan, and leaving there deposits of stern material.

The Ice Age influenced South Wales in several ways. rst of all the ice acted as a denuding agent, and the ice s widened or deepened some valleys along which it moved. total effect, however, it must be made clear that the nudation resulting from the ice is very slight compared h that resulting from the work of the rivers; in the main, rivers had carved out practically all the existing valleys South Wales before the Ice Age, and the ice in its move-nt took advantage of them as the easiest lines of move-nt. On the other hand, as it melted away, the ice posited the material which it had worn away. This ice-ne material is spread over the more glaciated parts of uth Wales in the form of irregular banks and mounds. is generally a boulder clay, a mixture of boulders of all es, often scratched by ice, mixed with finely powdered rock gments, while in many cases it merges into a gravel. These rift' or superficial deposits are shown on the Drift editions

of the maps of the Geological Survey, and naturally they ten to obscure the structure of the solid rocks, which alone ar shown on the 'Solid' maps. Drift deposits are commonl found in the river valleys; in many cases the ice left th valleys almost choked up with drift, and the rivers hav since been working to re-excavate their valleys, so that th effect of the Ice Age has in many cases been the reductio and not the enlargement of the river valleys.

The ice-sheets receded when the climate became warme and probably appeared as valley-glaciers; during pauses i their retreat they built up terminal moraines which now forn dams more or less completely across the valleys, as at Glais i the Tawe valley.

CHAPTER II

THE RELIEF OF SOUTH WALES

THE physical features of South Wales have resulted from the changes which have been sketched in the preceding chapter. Broadly, it may be suggested at in South Wales there are two groups of plateaux:

(1) an elevated plateau tract, forming the main portion of the coal-field and its borders, and extending northwards into Central Wales; and

(2) a series of low coastal plateaux, in south Pembrokeshire, Gower and the Vale of Glamorgan (figs. 5 and 6).

The form of each of these areas resulted from a period of nudation during which the region was planed down to proximately one level, followed by a period when the whole South Wales was uplifted to a considerable height above e sea. The more elevated plateau consists of Palæozoic cks which were probably planed down in late Mesozoic nes and were raised far above the sea at the end of the etaceous period. The coastal plateaux also consist in part Palæozoic rocks (partly concealed in the Vale of Glamorgan a cover of Trias and Lias) which were first worn down in rly Mesozoic times but were finally planed down by the a in Pliocene times, having been subsequently elevated rough some 200–400 feet.

While the broader features of each of these regions may be nsidered to have originated from the uplifting of a planed-wn surface, the diversified relief within these major regions s resulted mainly from other causes, of which perhaps the ost important is the distribution of hard or resistant rocks d of soft or easily eroded rocks. The softer rocks have

FIG. 5.—Sketch Map of the Relief of South Wales

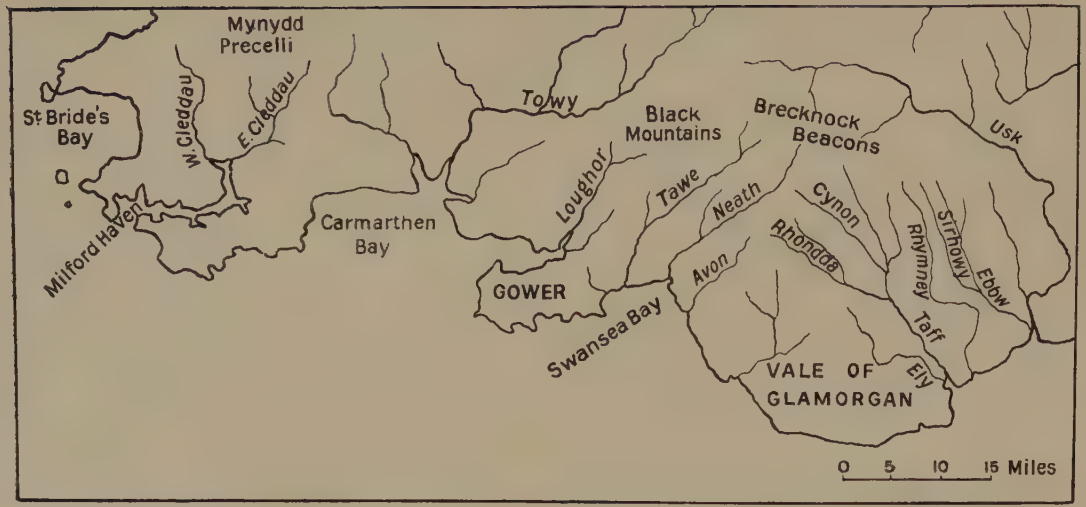


FIG. 6.—Sketch Map of South Wales to show Rivers and some other Features (compare fig. 5)

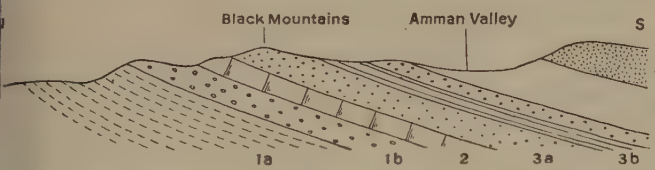
become worn down below the general level of the plateaux leaving the harder rocks standing up to form the high ground. The most important of the hard rocks occurring in the area under discussion are the sandstones and conglomerates in the upper part of the Old Red Sandstone, the Carboniferous Limestone, the grit and quartzite beds in the Millstone Grit, and the Pennant Sandstones of the Coal Measures. Generally speaking, the rocks occurring between these are much softer; the red marls of the Old Red Sandstone are quite soft except for thin bands of sandstone, and give rise to lower country, while parts of the Millstone Grit, and the Lower Coal Series and Upper Coal Series, consist of soft clay rocks or shales.

Since the coal-field is a basin, with the Coal Measures underlain in turn by Millstone Grit, Carboniferous Limestone and Old Red Sandstone (fig. 4), these rocks crop out in regular succession around its borders, which thus present a series of more or less parallel ridges with intervening hollows. Each such ridge or escarpment follows the outcrop of a group of hard rocks.

The Borders of the Coal-field

The highest ground in South Wales lies to the north of the coal-field, where the outcrops of Old Red Sandstone, Carboniferous Limestone and Millstone Grit trend broadly from east to west along the northern margin of the coal-field, dipping with an average dip of less than 20 degrees to the south. In the east of this area the general height rarely falls below 800 feet and across this upland tract the escarpments formed by the harder rocks of the Old Red Sandstone, the Carboniferous Limestone and the Millstone Grit may be traced (figs. 7 and 8). The most striking feature is formed by the harder sandstones and quartz conglomerates near the top of the Old Red Sandstone, which attain their greatest development in Breconshire, and give rise to the Brecon (or Brecknock) Beacons. Some six miles north of Merthyr Tydfil these rise in several peaks to more than 2,500 feet (fig. 8), while to the west the escarpment is continued in the Fans and Fforest Fawr, over 2,300 feet high, near the head of the Tawe valley. This escarpment is a bold feature, rising sharply from the

ain of Brecon with its fertile soil of deep red marls ; the rthern face shows a precipitous scarp of bare sandstone cks, while on the southern side the ridge slopes more evenly th the dip of the rocks. To the east, a similar feature curs in the Black Mountains, between Crickhowell and

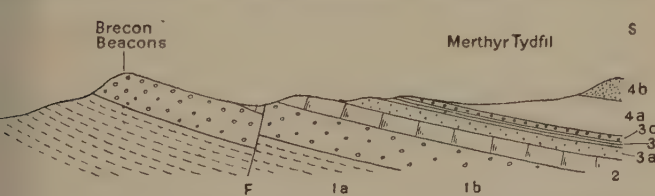


. 7.—Geological Section through the Black Mountains of Carmarenshire and the Amman Valley, Carmarthenshire, showing the escarpments made by the harder rock groups

Old Red Sandstone (*a*, mainly marls ; *b*, sandstones and conglomerate) ; 2, Carboniferous estone ; 3, Millstone Grit (*a*, Basal Grit ; *b*, shales ; *c*, Farewell Rock) ; 4, Coal Measures (*a*, Lower Coal Series ; *b*, Pennant Sandstone).

ay, but further west the Old Red Sandstone scarp becomes s prominent, and it is a much less impressive feature near andilo, whence it may be traced to the sea coast near rryside.

South of this Old Red Sandstone escarpment occurs the



. 8.—Geological Section through the Brecon Beacons and Merthyr Tydfil

F, fault. Index to shading as in fig. 7.

ge made by the Carboniferous Limestone. On the north the coal-field this is not usually more than a few hundred t in thickness, and its outcrop it correspondingly narrow, ely exceeding a mile in width, and occasionally dwindling, near Blaenavon, to less than a quarter of a mile. The arpment of the Carboniferous Limestone is therefore not high as that of the conglomerates of the Old Red Sand-

stone, but it can be traced continuously from near Kidwelly to the eastern end of the coal-field ; in some places it gives rise to a distinct and separate feature, as near Llandebie, or give rise to an extensive upland area, as near Ystradfellte at the head of the Vale of Neath ; elsewhere it forms merely a subsidiary feature on the scarp of the Millstone Grit, as in the Black Mountains of Carmarthenshire (fig. 7), and in Blorenge, near Abergavenny. Scenically the country built up by the Carboniferous Limestone is of very different character from that of the Old Red Sandstone. It gives rise generally to infertile country and on high ground there is little soil and the ground is rarely cultivated, while in many places the rocks form rough grey crags. In some parts the outcrop of the Limestone is well wooded. Since the Limestone is relatively soluble in water the streams in these regions tend frequently to flow underground along channels which have been dissolved through the rocks, leaving their original valleys dry except during times of unusually heavy rainfall. Thus in many places the rivers flow underground for some distance as they cross the belt of country occupied by the outcrop of the Carboniferous Limestone, appearing again at the surface as they reach the succeeding insoluble rock. Good examples of dry valleys and underground streams are to be seen near Ystradfellte.

In the same area, north of the coal-field, the Millstone Grit varies in its development, as noted in the previous chapter. The grits are thickest north of the Amman Valley in Carmarthenshire, where they form the barren moorlands called the Black Mountains, which rise to over 2,000 feet (fig. 7). This high escarpment overshadows that of the Old Red Sandstone in that region, but further to the east, in the area where the Old Red Sandstone builds the Fans and the Beacons, the Millstone Grit gives rise to less conspicuous escarpments (fig. 8) which are nevertheless quite traceable to the north-eastern margin of the coal-field, near Blorenge.

On the eastern and south-eastern margins of the coal-field the same sequence of rocks occurs, but some of the rocks are thinner and the narrow escarpments to which they give rise are not usually higher than about 800 feet above sea-level.

nly two escarpments characterize the coal-field border north Newport and Cardiff. That of the Old Red Sandstone is ell marked in Craig Llanishen, north of Cardiff, while the arboniferous Limestone forms Cefn On and Garth Wood ittle Garth), near Cardiff. The Millstone Grit consists ainly of shales and gives rise to low ground. These ridges the coal-field border are inconspicuous further west, etween Llantrisant and Port Talbot, and consequently try into the coal-field is much easier in that area. West Bridgend, a hard band among the shales of the Millstone rit gives rise to a similar escarpment in Cefn Cribbwr, near enfig.

The Physical Features of the Coal-field

The physical features of the coal-field itself may next be nsidered briefly. The coal-field is cut into two separate rtions by Carmarthen Bay, and the Pembrokeshire portion ay well be dealt with separately at a later stage. The cks of the main part of the coal-field include three groups, mely the Lower Coal Series, the Pennant Sandstone Series d the Upper Coal Series. Of these, the Pennant Sandstone cupies by far the largest area, the Lower Coal Series out-pping mainly in a belt around the margin of the coal-field, d the Upper Coal Series occurring in several synclinal eas, between Llanelly and Llansamlet, at Dyffryn, near eath, at Caerphilly and at Gelligaer (fig. 4). Both the pper and Lower Coal Series consist mainly of shales, and ese districts have been worn down below the general level the plateau, which is built by the Pennant Sandstone.

The Pennant Sandstone plateau (known in the east as aenau Morganwg) occupies the main part of the coal-field, ing to nearly 2,000 feet in the north in Craig y Llyn, and pping gently to about 600 or 1,000 feet on the southern rgin. Probably representing an elevated plain of marine nudation formed during late Mesozoic times, it has been ssected in varying degrees by the rivers which cross it, t much of the uplands still retain the featureless character the plateau. The Pennant Sandstone gives a very sandy l, and the hills of the coal-field are frequently barren, devoid

of trees, and suited only for pasturing sheep. The Pennant Sandstone is most typically developed in the east of the coal-field, while in the west the series contains some shales; as a result, the plateau features are less typically displayed in the west, where the valleys are often wide and the hills more rounded. On the margin of the plateau the Pennant Sandstone forms a prominent escarpment standing out from the lower ground which is occupied by the outcrop of the Lower Coal Series.

In the Pembrokeshire portion of the coal-field the Upper Coal Series and the Pennant Sandstones are missing, and the relatively shallow syncline contains only the Lower Coal Series. Accordingly there are no features comparable with the Pennant plateau of the main part of the coal-field, the Pembrokeshire portion of the coal-field being more or less continuous with the coastal plateau of the south of the county, rarely rising over 300 feet. To the north of the coal-field in east Pembrokeshire are outcrops of Millstone Grit (mainly shales), Carboniferous Limestone (a very thin development), and Old Red Sandstone; the latter gives rise to higher ground north of Ludchurch. Further west, near Haverfordwest, the Old Red Sandstone and Carboniferous Limestone are overstepped by the Millstone Grit, which then rests directly on folded Lower Palæozoic rocks and the normal features of the coal-field border are not present along this portion of its north-western margin.

The Coastal Plateaux

West and south Pembrokeshire form part of the coastal plateau. The land rarely rises above 300 feet except in the more inland parts, and viewed from about that height the land usually appears to be level and featureless, while even hard rocks, such as the Pre-Cambrian igneous rocks near Johnston, give rise to no very marked feature. The plateau was probably planed down to this level surface during the Pliocene submergence, but the differences in the hardness of the rocks have led to more rapid erosion in certain areas, and the relief is beginning to reflect the grain of the land. Thus south Pembrokeshire consists chiefly of Old Red Sandstone

ıd Carboniferous Limestone, folded in sharp anticlines and ynclines trending approximately east-west, and the soft rocks ccurring in these folds have given rise to valleys and hollows rresponding in position with the folds (see fig. 16). In some aces, as at Freshwater East, soft Lower Palæozoic shales ave been exposed in the core of an anticline, while in other ses, as at Pembroke, the valley follows the axis of a syncline.

In some respects the Gower Peninsula is very similar in rm to that of south Pembrokeshire. Like that region, ower is built up mainly of Old Red Sandstone and Carboniferous Limestone, folded in sharp east-west folds, with a nall area of Silurian in the core of an anticline, and with illstone Grit (shales) preserved in the deeper synclines; ost of south Gower lies near the 200-foot contour line, but rther inland the plateau rises to just over 400 feet above a-level. Soft shales in the Millstone Grit in the syncline Oxwich are lower than the general level of the plateau. n the other hand, the sandstones and quartz conglomerate the Old Red Sandstone which outcrop in the anticlinal eas (Cefn-y-Bryn and its western continuation Llanmadoc ill, and Rhossili Down) give rise to high ground rising arply above the plateau to over 500 feet. These patches Old Red Sandstone, which include rocks identical with those rming the Brecknock Beacons, must have stood as islands ove the Pliocene sea which finally cut the plateau, resisting their hardness the action of the waves which planed down e Carboniferous Limestone, itself of course a comparatively ugh rock. Apart from these patches, most of south ower is occupied by Carboniferous Limestone, and exhibits ny of the features of limestone country. There are merous caves, and several of the rivers flow underground part of their course. Over much of the area a thin cover superficial deposits, such as boulder clay, forms a fertile l, but elsewhere on the Limestone there is little soil.

The structure of the Vale of Glamorgan (Bro Morganwg) in some respects like that of Gower and south Pembrokeire, but it differs chiefly in that the Mesozoic rocks, namely e Trias (Keuper Marl), Rhætic, and Lower Lias, have not en stripped off by subsequent denudation, and much of

the area is covered by these rocks (fig. 4). South of Cowbridge and Bridgend the greater part of the region is occupied by almost horizontal beds of Lias, consisting of thin, alternating bands of limestone and shale, while the red Keuper Marl covers a wide area to the east of this near Cardiff and occurs in smaller patches as far west as Porthcawl. Where the Mesozoic rocks have been removed, Carboniferous Limestone and Old Red Sandstone outcrop, and these emphasize the similarity of the region to Gower, having been folded similarly in late Carboniferous times into east-west anticlines and synclines, which, however, are not nearly so sharp as those of Pembrokeshire.

The Vale is a low plateau, rising to about 200 or 300 feet above sea-level, reaching a greater height in the areas occupied by the Carboniferous Limestone. Between Cardiff and Newport, and stretching thence into the plain of Gwent, are low lands built up of the soft red marls of the Old Red Sandstone

CHAPTER III

THE RIVERS AND COASTS OF SOUTH WALES

THE general arrangement of the rivers of South Wales may be seen from figs. 5 and 6, which give the salient features of their distribution. The most nportant rivers of the area may be considered in two groups, rst, those which flow towards the south-east or south-south-ast, and secondly, those which flow approximately towards ie south-west. The first group is mainly to be found in ie east of the area, the second group further to the west.

The Rivers of South-East Wales

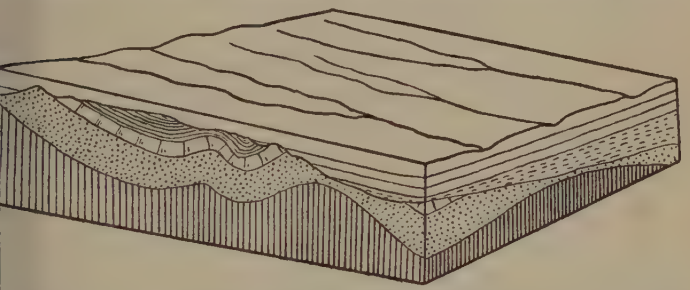
The rivers of the eastern part of South Wales occur at irly regular intervals of one or two miles and follow courses hich are approximately parallel. Few of these rivers have ıy tributaries of any importance, apart from streams flowing the same general direction. Thus the River Taff receives ı its right bank the Cynon and the united Rhondda streams, though these rivers are practically parallel throughout ost of their courses. Similarly, further east, the Bargoed hymney and the Rhymney unite at Bargoed, while the rhowy and Ebbw join at Crosskeys. Several of these reams, such as the main stream of the Taff, rise on the slopes the Beacons ; others, as the Cynon, Rhymney and Ebbw, se on the dip slopes of the Carboniferous Limestone or the illstone Grit on the northern edge of the coal-field ; while hers, such as the Rhondda Fawr and the Rhondda Fach, have eir sources within the coal-field itself. All these rivers w in valleys of similar character. Generally speaking, ey are narrow, and relatively straight, with steep sides. the lower part of their courses there is usually a narrow

strip of alluvial deposits, but for the most part there is little fertile country beside the rivers, the bare hills of Pennant Sandstone rising abruptly from the valley floor to the level of the plateau. Where the rivers cross the shales of the Lower Coal Series or the Upper Coal Series the valleys widen somewhat; this is especially the case on the north of the coal-field, where the gentler dip of the rocks gives rise to a wide outcrop of the Lower Coal Series (fig. 4). On the south of the coal-field the outcrops are narrow, and although each valley widens slightly there as it crosses the outcrop of the softer shale groups, each river makes its exit from the coal-field by a series of gorges cut through the Pennant Sandstone, the Carboniferous Limestone and the hard beds in the upper part of the Old Red Sandstone. These gorges are clearly seen in the case of the River Taff, near Taff's Well and Tongwynlais, in the case of the Rhymney, near Machen, and in the case of the Ebbw, near Risca. The Afon Lwyd rises on the edge of the coal-field and follows a course along the strike of the rocks of the coal-field border, leaving by a gorge cut through the Carboniferous Limestone at Pontypool.

This very simple arrangement of the rivers was probably determined by some cause at an early stage in the evolution of the present land surface. That cause was not in any way related to the present geological structure, for each river flows directly across the main structures. There can be little doubt that this system of south-south-east flowing streams was initiated when the land was raised at the end of Mesozoic times, probably from below the Chalk sea. It is generally believed that at that time the Palæozoic rocks were buried under Mesozoic sediments, the highest of which, the Chalk, may have extended far to the north into Central Wales. This newly elevated portion of the sea floor, smooth in its outlines and devoid of any prominent features, was in South Wales inclined gently towards the south-south-east, and as a consequence the drainage which then developed followed the dip of the surface (fig. 9). In spite of the fact that the rivers, assisted by other agents of denudation, have now removed the Chalk and any other Mesozoic rocks which may have existed, and have cut down deeply into the Palæozoic

cks below, they have in the main kept to their original rections. Thus these south-south-east flowing streams ere originally 'consequent' streams with their direction termined as a consequence of the dip of the Mesozoic rocks, ıt with the removal of these rocks the drainage has been uperimposed' on the series of Palæozoic rocks in which e structures have no relation to the drainage direction.

Naturally, the simple plan of the original consequent reams may have been modified in certain details. For stance, it is highly probable that river-capture has occurred several instances. Thus the Bargoed Taff was probably tributary of the Rhymney, but has been captured by the



G. 9.—Diagram to illustrate the Probable Origin of the River Systems South Wales, showing gently dipping beds of Chalk and other esozoic rocks resting upon folded Old Red Sandstone and Carboniferous rocks

ster cutting Taff, leaving dry a portion of its original valley tween Treharris and Ystrad Mynach, a small stream now wing past Llancaiach along the old valley of the Bargoed ıff but in the opposite direction to that of the original river. is further probable that the Rhondda Fawr, if not also the hondda Fach, formerly flowed through the gaps above Ton-efail into the Ely valley, these headwaters of the original y having also been captured by the more powerful Taff g. 10). The dry gaps formerly occupied by these rivers ve in each case been occupied by important routes.

Further modifications of the simple system of consequent reams have arisen as a result of the differing hardnesses of e rocks over which the rivers now flow. The most notable

instance is the Rhymney, which turns eastwards near Caerphilly and keeps its course along the tract of Upper Coal Series before leaving the basin at Machen.

A similar series of south-south-east flowing streams can be recognized outside the coal-field, both to the north and east. As in the coal-field area, the consequent direction is best seen where the valleys are cut deeply into upland areas of resistant rocks; in such areas the post-Cretaceous plateau surface is still to be recognized, but in the areas of softer rocks where denudation has progressed more rapidly there has been more opportunity for modification of the original drainage systems. Thus the Black Mountains of the Breconshire border are deeply trenched by a series of parallel valleys with a south-south-east direction, modified by capture in the south near Abergavenny, where the development of subsequent tributaries to the Usk on the west and to the Monnow on the east has led to a most interesting series of captures of the original streams. On the lower ground to the south and east of this the rivers are still less regular in their arrangement.

FIG. 10.—Sketch Map showing the Relations of the Rhonddas to the River Ely

The supposed former courses of the Rhondda Fawr and Rhondda Fach are indicated by dotted lines.
The shaded area represents land over 1,000 feet.

THE RIVERS OF SOUTH-WEST WALES

The river systems of the western portion of South Wales are more complex. As we have already pointed out, the most important rivers, namely the Neath, the Tawe and the Towy, flow towards the south-west or the west-south-west (fig. 6). Nevertheless, these are not the dominant directions of the greater number of the streams in this part of South

Vales, especially of those in the upland areas, which flow nerally from north to south. This direction is seen in eat numbers of small streams, on the dip slopes of the Black ountains of Carmarthenshire and on the plateau of Pennant ndstone within the coal-field. Larger streams having this rection include the Dulais, a tributary of the Neath, the ydachs, tributaries of the Tawe, and the Loughor with its ibutaries the Gwili and Morlais. It is possible that these uth-flowing streams in this part of South Wales represent e original consequent streams which may have been veloped on the Chalk cover in early Tertiary times in the me way as the parallel streams of south-east Wales. This ew would lead to the supposition that the uplift which curred at the end of Cretaceous times was slightly irregular, e land sloping to the south-south-east in the eastern part South Wales but to the south further west.

If these south-flowing streams in the west of South Wales present the original consequent streams, as we would ggest, it is clear that the river system has undergone greater odification here than in the area further east. This has sulted from several causes, first, from the existence in the ea of notable belts of crushed and broken country, and condly, from the less sandy development of part of the nnant Sandstone Series, allowing of the more rapid erosion the rocks on which the rivers were superimposed.

The Rivers Tawe and Neath follow courses which are almost rallel, and their valleys are straight and simple, with a der deposit of alluvium along the floor than is usual in ny of the rivers of South Wales. These rivers are much ore mature than those previously dealt with, the gradient ing comparatively gentle for some miles above the mouth. us in the case of the Neath the river only falls through o feet in the last 10 miles of its course, although above Glyn ath the gradient is much steeper, the river falling through out 1,900 feet in less than 10 miles. The course of the ath from above Glyn Neath to the sea, and that of the we from the neighbourhood of Ystradgynlais, have been termined by the two belts of intensely disturbed rocks scribed in the last chapter. In these zones of shattered

and weakened rocks the rivers have been enabled to cu rapidly downwards, so that they have become much mor mature than other rivers or even their own tributaries on les disturbed ground. Thus the headwaters of these rivers an their tributaries fall with very steep gradients into the mai valleys, and the extra cutting power possessed by the torrent- like tributaries has led to the development of beautiful gorge and numerous waterfalls, as in the region above Pont Neat Vaughan, at the head of the Vale of Neath.

It is notable that both the Neath and Tawe have very fe tributaries on their left banks, but several large ones on thei right banks. These tributaries have already been referre to as examples of the south-flowing rivers which may repre- sent in this area the original consequent drainage. It i probable that before the development of the Neath and Taw these tributaries flowed across the land where the Neath an Tawe now have their valleys. One example may serve t illustrate the point in question ; the Upper Clydach River flowing southwards at Cwm Gors through a wide valley which appears too large for the river, may formerly have flowed across the present Tawe valley at Pontardawe through the dry gap of Alltwen to the sea near Neath (fig. 11). This valley has determined the course of an early route from Neath which crossed the Tawe at Pontardawe. The develop ment of the Tawe and Neath apparently led to the capture o the south-flowing streams, which would thus appear to b much older than the Neath and Tawe. The latter developed rapidly on account of the advantage which they possess i flowing in belts of intense faulting and shattering.

Along much of its course the River Towy follows another belt of weakness, namely the crest of a great anticlinal fold in the Lower Palæozoic rocks, which we have referred to as the Towy Anticline. The Towy has also been able on account of this advantage to wear down its valley to near base-level for many miles above its mouth, and the river meanders calmly over a wide alluvial plain, as for instance between Llandilo and Carmarthen. It too has captured some of the south-flowing streams. The Dulas, which now joins the Towy near Llandilo, probably formed at one time the head

aters of the Loughor. The latter now rises in the low ground ar Derwydd, not far from the northward-flowing Cennen, hich probably represents a reversal of the original drainage rection.

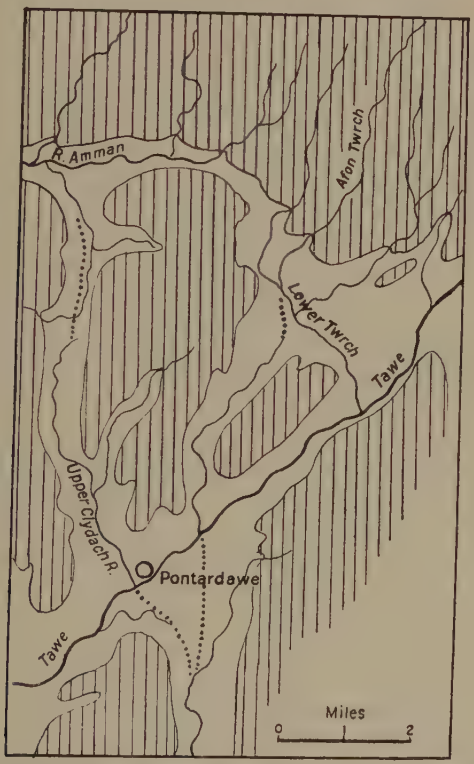


FIG. 11.—The Rivers of the Upper Part of the Tawe Basin

ible lines of the early drainage are shown by dotted lines, river capture having occurred the development of subsequent streams along the soft rocks of the Lower Coal Series, the case of the Lower Twrch; and (ii) by rapid erosion along the belt of disturbance in the Tawe valley.

The shaded area represents land over 600 feet.

was pointed out above that the river systems of western th Wales have also undergone greater modification than e of south-eastern Wales in regard to the influence of l and soft rocks. The Pennant Sandstone in the east

is mainly sandstone with little shale, while that in the west contains much shale in its upper part. As a result the valleys in the west are generally wider, with sides more gently sloping while there has been a tendency for the development of tributaries along the outcrops of the softer rocks, and particularly along the outcrop of the Lower Coal Series. These 'subsequent' streams, following the strike of the Coal Measures, have in some cases captured the original drainage and have become more important than the original rivers. Thus the Lower Twrch follows the outcrop of the Lower Coal Series between Cwmtwrch and Ystalyfera, capturing the Gwysg, which appears formerly to have flowed through the gap on the south of the present valley of the Lower Twrch (fig. 11). The Amman and Gwendraeth valleys similarly occur on the outcrops of the soft Lower Coal Series, and represent adjustments of the drainage to the structures of the rocks on which the original drainage has been superimposed. Many minor adjustments of a similar nature can be seen in various parts of the area.

In the region of the Loughor Estuary, the Loughor and the Afon Lliw turn sharply to the west along the syncline which includes the outcrop of the Upper Coal Series; this may be compared with the change in the course of the Rhymney, already noticed in the east of South Wales. In the present case, at least, it is possible that the change in direction may have been caused by slight earth-movements leading to a deepening of the basin, during Tertiary times.

As a result of these changes, the drainage of South Wales has become to a large extent concentrated on Carmarthen Bay, Swansea Bay, and on the coast near Cardiff and Newport (fig. 6). The belts of weakness which have proved so advantageous to the Tawe and the Neath may perhaps have weakened the coast-line and so led to the formation of Swansea Bay, although there is no evidence at present that they extend so far to the south-west. The remaining areas of South Wales, namely south Pembrokeshire, Gower and the Vale of Glamorgan, are on the whole drained by rivers of no great size, and their arrangement calls for no special comment.

The rivers of South Wales, except the Towy, are relatively nall and are usually very rapid. They are not of much e for transport. As their courses are short and as much of eir water is derived from surface waters rather than from rings, they are liable to rapid flooding and to periods of mparative dryness, and they are not likely to be much ed for purposes of water power.

It is clear that the present distribution of the drainage was ainly determined before the glacial period, and that not ly was the main work of carving the valleys done by the vers before that time, but that the glaciers generally followed e valleys, and led perhaps to less modification of the drain- e system than was the case in many other areas. Some nor features are probably due to the blocking of certain lleys by the ice, leading to the cutting of new out-flow annels, but on the whole these are not of great significance South Wales. One example occurs at Cockett, near Swan- a, and another at Cwrt-yr-ala, near Cardiff.

The Coast of South Wales

The features of the coast of South Wales, like the features the relief, have been determined by several factors, which lude, first, relatively recent uplift and depression, and ondly, the effects of resistant and non-resistant rocks. a result of the elevation which followed the Pliocene sub- rgence, as already noted, there are low plateaux rising 200 and 300 feet along much of the coast. As a result of re recent subsidence, which is perhaps still continuing, ny of the valleys have been drowned and the low lands ar the coast have been submerged.

The finest instances of drowned valleys are Milford Haven d the valley of the Cleddau (figs. 2 and 6). Milford Haven a typical sea-drowned valley, originally eroded by a river ng a line which was perhaps a belt of shattered rock. ner valleys in South Wales would similarly be converted o narrow inlets if the deposits which partly fill them were noved ; the valley of the Tawe near its mouth is filled by reat depth of superficial deposits, the removal of which uld lead to the formation of an inlet extending for some

miles above Swansea, the floor of the pre-glacial valley having been carried by subsidence far below the present sea-level. This same subsidence has naturally enlarged Swansea and Carmarthen Bays, but has not caused any encroachment of the sea where rocky cliffs rise above the shore, as along the coast of the Vale of Glamorgan.

Since these areas of high cliffs are generally (although not always) found where the hard rocks form the country, it follows that generally the hard rocks tend to stand out as headlands, while the soft rocks, or the regions of shattered rocks, tend to form bays, not merely because the sea erodes these rocks more quickly, but because subsidence admits the sea to land which has already been lowered by sub-aerial agencies.

Thus the promontory of St. Davids Head is formed by the Pre-Cambrian and associated hard rocks ; Skomer Island and the mainland near Marloes is composed chiefly of tough Ordovician volcanic rocks, while the area between them forming St. Bride's Bay, consists of marl of the Old Red Sandstone and of Coal Measure shales (fig. 2).

In both south Pembrokeshire and Gower the rocky coast is formed chiefly by Carboniferous Limestone, the Millstone Grit shales giving rise to bays as at Lydstep Haven and Oxwich Bay. In sharp distinction to the rugged coasts of west Wales is the cliff-bound coast of the Vale of Glamorgan, where nearly horizontal Lias rocks give rise to almost vertical cliffs about 100 feet high, which form an almost unbroken line from Southerndown to Barry. At Barry small patches of Carboniferous Limestone again reproduce something of the scenery of Porthcawl, Gower and south Pembrokeshire, but the coast near Penarth consists of high cliffs of red Keuper Marl. From near Cardiff eastwards the coast is bordered by level stretches of estuarine mud and alluvium, most of it of comparatively recent date, which has collected since the coast began to subside.

At many points along the coast are sand-dunes. These are best seen along the eastern shore of Swansea Bay (fig. 15) as well as in parts of Gower and further west. The dunes consist of sands which have been blown up from between

de marks, and since the prevailing winds are from the uth-west, the dunes are most frequently formed along the stern parts of the bays. They occasionally rise to a nsiderable height, and in some parts have invaded the nd and buried villages, as at Kenfig and Nicholaston. In any cases the growth of sand-dunes along the coast has mpeded the drainage, and behind the coastal dunes the nd is often boggy. Crymlyn Bog, near Swansea, is one a series of examples which may be followed along the stern shores of Swansea Bay.

CHAPTER IV

CLIMATE

THE climate of South Wales is similar, in general, to that experienced by other areas on the western seaboard of Britain. It has mild winters and cool summers, and it receives an ample volume of rainfall.

Differences in topography and in proximity to the sea bring about characteristic differences in climate which make it desirable to divide the area into three parts :—

(*a*) the country west of a line from Swansea to Aberystwyth.

(*b*) the Vale of Glamorgan with Monmouthshire.

(*c*) the highland region of the north-east of South Wales.

The first area constitutes west Glamorgan and the whole of the counties of Carmarthen, Pembroke and Cardigan. It is roughly triangular and peninsular, being bounded on the north and west by Cardigan Bay and St. George's Channel, and on the south by the Bristol Channel. The country is relatively low except for the plateau of Plynlimmon and its extensions southwards.

The Vale of Glamorgan and the lowlands of Monmouth together represent a smaller area which may be regarded as a part of the Severn lowland, lying between Exmoor and the Welsh uplands.

The highland area is the southern portion of the tableland of Wales and includes, in our area, the plateau of north Glamorgan and much of the county of Brecon.

Temperature

The west Wales region in the winter months (Nov.–Feb.) is one of the mildest areas in the British Isles. Day temperatures are about 3° Fah. warmer than they are in the east

England. A more important feature, however, is the ildness of the nights, the average temperature of which is ven degrees above freezing point, or five degrees warmer an nights on the east. The cause of this is the warming fluence of the western ocean and in particular of the neigh- uring waters of Cardigan Bay and the Bristol Channel.

By February these are at their lowest temperature, and us it is in this month that nights in Pembrokeshire are ldest. Even at this time, however, frosty periods are few, nd snow seldom persists on the ground for more than a day two. As a result plants survive which perish elsewhere, nd the garden hedges of fuchsia which are common in south embrokeshire are a striking proof of the mildness of the inter season.

Throughout the rest of the year the area is cool, for then e sea influence lowers the temperature of the air in the aytime. At night it operates in the opposite direction and gain the nights are markedly warmer. The result is that e mean temperature tends to mask the differences in day mperature between the east and the west, particularly ose that occur in spring.

The Vale of Glamorgan and Monmouthshire are best nsidered as a transition area between the milder west and e more extreme temperature conditions of the Midlands England. Temperature gradients are, as a rule, remark- ly steep from Swansea eastwards during the night in nter, and during the day in summer. The influence of e western sea dies away and even the Bristol Channel has all effect, except that it warms the nights in summer, and ves the southern coast of Wales remarkably regular temper- ures throughout its whole length in that season.

The high land in the north-east of South Wales is still less luenced by the moderating influence of the sea. Its nperature is also governed by the fact that there is a fall approximately 3° Fah. for every 1,000 feet increase in itude above sea-level. The general effect is that the area periences very cold nights in winter, so that periods of frost d snow are more frequent and more severe than in the vlands.

Similarly the mean summer temperatures are lower chiefly because of the cooler nights. Conditions in the narrower valleys are little different from those in the highland itself. In winter the heavy cold air in still frosty periods tends to roll down from the plateau, and owing to the deepness of some of the valleys much of the shortlived winter sunshine is lost. The temperature in summer is raised by the radiation of heat from the valley sides, and by the absence of movement of the air.

The following normal monthly temperatures are approximate and are in degrees Fahrenheit :—

	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.
Pembroke—												
Day . . .	46	47	48	52	57	62	66	64	62	56	51	48
Night . . .	39	39	39	42	46	51	56	55	53	48	43	41
Swansea—												
Day . . .	46	47	49	54	59	63	66	66	64	56	51	48
Night . . .	37	38	38	41	45	51	55	54	51	45	40	40
Cardiff—												
Day . . .	45	46	49	55	61	67	68	69	65	57	51	47
Night . . .	36	36	37	41	46	51	55	55	51	45	40	38
Newport—												
Day . . .	45	46	50	55	62	67	69	69	65	56	50	46
Night . . .	35	35	36	40	45	50	54	54	50	44	39	37
London—												
Day . . .	43	45	50	56	62	68	71	70	66	57	49	45
Night . . .	34	34	36	40	44	50	54	54	46	44	39	36

Sunshine

The western region is the sunniest portion of Wales. The coast of Carmarthen Bay from Tenby to west Gower has a daily average throughout the year of four and a half hours, being equal in this respect to the south and south-east coasts of England (fig. 12). This fact, coupled with the mild temperatures which usually prevail, makes this coast suitable for the establishment of health resorts. The claims of Tenby are well known, but west Gower has not yet developed because of the absence of accommodation, and, in the past, of convenient means of communication. With the increase in motor transport there is no doubt that the area will grow in

portance. The Vale of Glamorgan and Monmouthshire, ough sunnier than the plateau of Wales, have fewer hours sunshine than the western area—an average of just over ur hours daily.

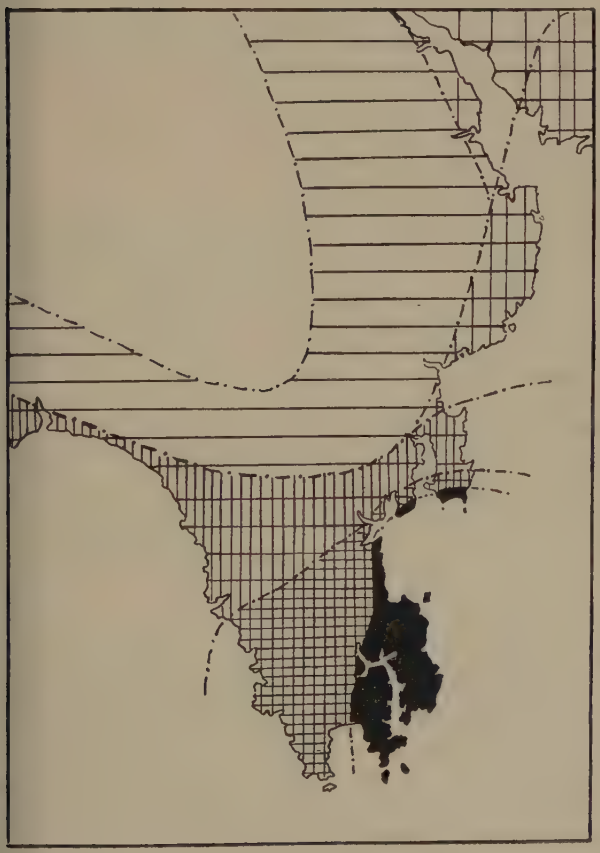


Fig. 12.—Map showing the Approximate Distribution of Sunshine
The area shaded black has an average of approximately 1,550 hours of bright sunshine per annum, while the area left blank has an average of 1,475 hours.

Rainfall

The most prominent controls of the weather in the British les are depressions, which most frequently move along the estern coast and more rarely across eastern Britain. In

such depressions the warmer and damper currents of air are forced to rise over the colder and drier ones so that condensation results, and produces the persistent falls of rain characteristic of the western districts. The ascent of the air over mountain slopes increases the volume of rainfall with such regularity that the lines of equal rainfall correspond remarkably with the contours, and the heaviest fall occurs just beyond the crest. When the air descends the downward slope its temperature rises at a greater rate than it fell in the ascent. The result is that the eastern side has warmer and drier conditions.

The average amount of rainfall received by the coastal fringe of the lowlands of South Wales is in the neighbourhood of 40 inches per annum, an amount about equal to that which falls in Dorsetshire and considerably more than that of a low-lying eastern county such as Cambridgeshire, which has less than 25 inches. Further inland, on the higher ground, the amount rises to values between forty and fifty inches.

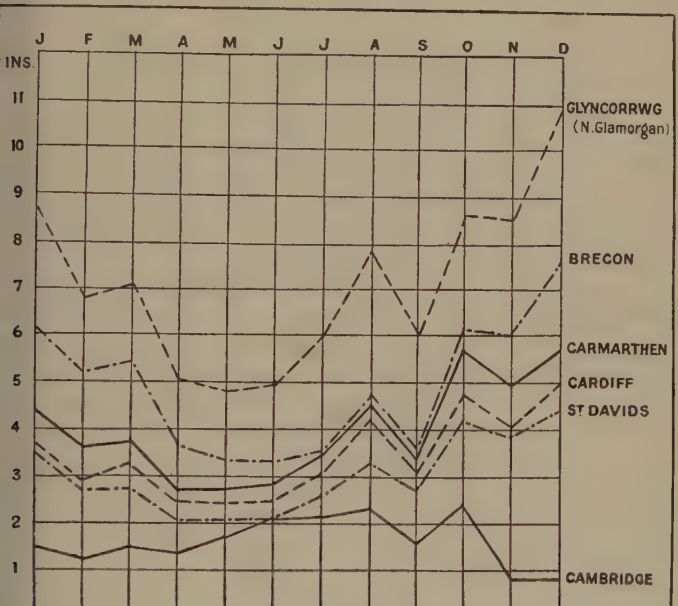
The heaviest rainfall in South Wales occurs on the plateau of Glamorgan, the Brecon Beacons and Fforest Fawr (the Black Mountains of east Carmarthenshire). Over the whole of this area more than 80 inches of rain fall annually, and on the higher portions an average of 100 inches has been observed over a short period of years.

The rainfall of the valleys in this upland area is controlled partly by the width and partly by the direction in which the valley faces. A narrow valley, whatever its direction, receives the rainfall of the surrounding highland, but a broader one facing the prevailing winds forms a drier re-entrant into the higher and wetter area—as in the case of the Towy. Valleys transverse to the prevailing wind direction, like the Rhonddas and the valleys of the eastern part of the coalfield, receive a similar rainfall to the uplands.

Over the greater part of Wales rain falls on 209 days in a normal year. The lowlands of the south, however, have a smaller number of rainy days—just under 200. The rain, in general, is of a drizzly type, so that, although it may be falling for a considerable period, the volume per day is not

sually high. For comparison we note that England has h the average 184 wet days, Scotland 216, and Ireland 223 er annum.

The graphs shown in fig. 13 are of the normal falls for eriods ending 1915. That for Cambridge is included for mparison and contrast. They show that the wettest



G. 13.—Graph of Monthly Normals of Rainfall for some representative South Wales Stations
(Cambridge is added for contrast and comparison)

onths at the Welsh stations are from October to March clusive, with the maximum fall in December. The months the spring and early summer are uniformly dry in highland d lowland. There is a rise in July to a maximum in August hich makes that month one of the four or five wetter months the year; September is everywhere dry. In Cambridge, hich is chosen as a representative station in the east Mid- nds, the annual volume of rain is much smaller, so that

the wettest month—October—is not very much wetter than the driest month—June—in one of the driest stations in South Wales—St. Davids. Most of the rain falls in the summer and autumn, with a dry period intervening in September.

CHAPTER V

THE GROWTH OF SETTLEMENTS

Prehistoric Times

MAN first appeared in South Wales towards the close of the Pleistocene times, when the ice-sheets which covered the country in the Great Ice Age were ginning to recede towards the north. He had existed for any thousands of years previously in other regions, and d flourished in those countries which had suffered less verely from the effects of the Ice Age, but he did not reach uth Wales until he came in pursuit of those animals which hunted. At this time, and probably for many centuries, uth Wales was a barren land with bitter winters.

During this period, the Palæolithic or Old Stone Age, man s primarily a hunter, following the herds of wild animals ich then roamed Europe ; he had no shelter except caves hollows in the rocks, and made weapons and tools of stone. e stone which had proved most suitable for his purpose s flint, commonly found in the Chalk in the east and south- t of England. In South Wales, flint is not very abundant, it only occurs in rather small pebbles at various places ng the coast, possibly representing the residue of a former tension of the Chalk, or perhaps brought into South Wales an ice-sheet moving eastwards from the Irish Sea. As esult, in Palæolithic times this almost flintless region was y sparsely populated, even along the southern coast, hough some evidence of Palæolithic man has been found, luding a skeleton in the Paviland Cave, Gower.

In the Neolithic or New Stone Age the climate became milder, l many of the open plains over which Palæolithic man had

hunted were covered by forests. Neolithic man thus became an agriculturalist, cultivating various crops and keeping domesticated animals. He made pottery and built huts, and attained a more settled life and a higher stage of culture. Although at this period stone was still used very largely for making weapons and tools, materials other than flint were employed; a variety of rocks was used in making polished stone axe-heads, while bone was introduced for the manufacture of various tools. The deficiency of flint was therefore no longer a factor in the peopling of South Wales.

Probably in Wales the New Stone Age lasted longer than in some parts of Europe, and doubtless the use of bronze was known in other places while stone was still used in our country, so that it is not possible to fix here the precise duration of the Neolithic and Bronze Ages. During these periods the inhabitants of South Wales lived on the open plateaux of the coal-field, where movement was unhampered by forest or swamp. Most of the river valleys were marshy and usually impassable to the early inhabitants, except at recognized fords. The sides of the valleys were covered by trees which spread on to the lower slopes of the hills, while a great part of the coastal tracts was probably likewise covered by forests, except perhaps along the more exposed portions. Thus numerous indications of the former existence of these people are to be found in the upland parts of South Wales; they include tumuli or ancient burial mounds, the stone circles and the encampments, although some of these are perhaps much more recent in date than the Bronze Age.

During the Neolithic and the Bronze Ages, South Wales received considerable additions to its population. Its earliest immigrants included people who came from the Mediterranean region. Among these, perhaps the most numerous were the short dark people with long heads whose descendants make up a large part of the population of South Wales at the present time. Other settlers from the same region apparently included a race of navigators, who chiefly influenced the coastal tracts of South Wales (and of other countries in south-west Europe), and whose wanderings are shown by the great stone tombs, called cromlechs or dolmens, such as

ose of Arthur's stone in Gower, of St. Nicholas, Glamorgan, nd of many parts of Pembrokeshire. On the other hand, nother race of men, which probably reached Wales before e Bronze Age, came from the central plains of Europe and ross England ; the spread of this race can be traced now by e distribution of curious drinking vessels called ' beakers ', om which these are known as the Beaker people.

Immigrants thus continued to reach Wales during the eolithic and the Bronze Ages ; their paths cannot always e traced, but some came from the more northerly parts of urope, others from the Mediterranean region. Since that me other races have contributed to the peoples of South ales, but the immigrants have mostly been members of ces living in the north of Europe, ' Nordic ' people, usually ll and fair and with long heads. Some of these later migrants have travelled westwards across England, others ve arrived by sea and settled at various places along the ast. Among the immigrants during the Iron Age were obably included a people who introduced Celtic speech, nich was gradually adopted by the earlier inhabitants. rther immigrants from the north of Europe continued to rive in post-Roman times, as will be noted later.

Thus the people of South Wales are a mosaic of racial ements, and are of very mixed origins. As is usual in such ses, the various types have not completely merged, and me individuals show clearly the physical characters of the rly races who settled here. Prof. H. J. Fleure believes that e descendants even of the Palæolithic men who first reached ales, in certain isolated regions such as the Black Mountains Carmarthenshire, have retained the cranial characters of eir ancestors of the Old Stone Age.

Roman Influences in South Wales

The Roman occupation of South Wales, which was com-eted by the close of the first century of the Christian era, as in the main a military one, and the Roman settlements the area were merely isolated posts connected with each ner by a network of paved ways, and acting under the neral control of the main base of Caerleon. The great

importance of this fortification is only now being revealed by excavation, and in addition to details of defence works, indications of a complete Roman town have been exposed. The influence of Roman culture both here and near Caerwent, acting over a prolonged period, must have been considerable. We may note as one of the slighter pieces of evidence of this, the remains of Roman iron smelting in several localities.

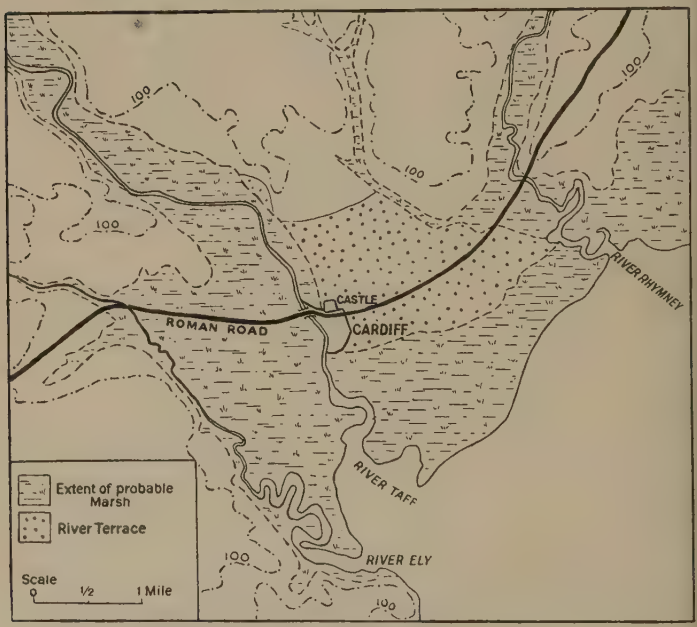
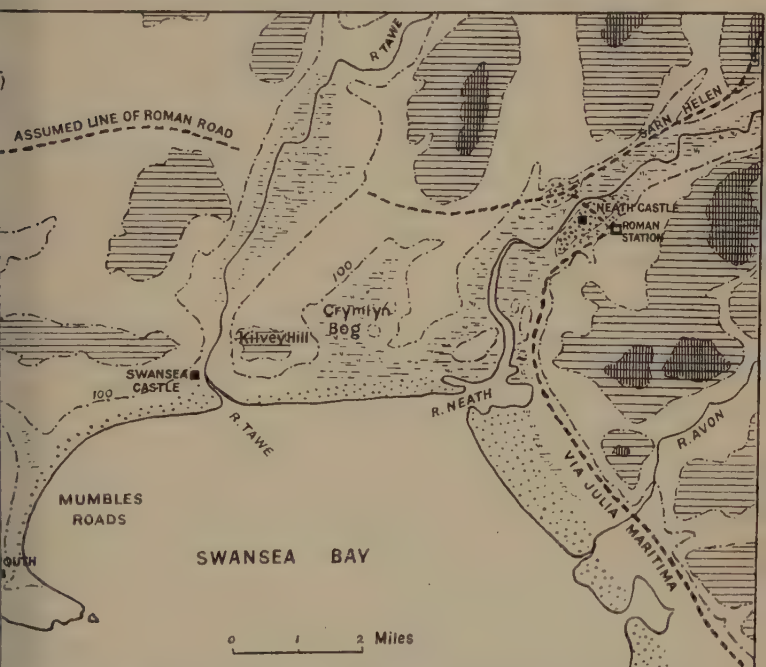


FIG. 14.—Some Factors which influenced the Site of Cardiff

The site of Cardiff was evidently used as a place of disembarkation of men and supplies, for it was defended by an extensive work placed where the 'road' crossed the Taff (fig. 14). The fort was situated on the western edge of a river-terrace. From this point, the Via Julia Maritima continued along the central part of the Vale, past an unidentified Bovium, to a point near the coast of Swansea Bay, and thence between the coast and the plateau-edge northwards

to a place where a river-terrace made possible a comparatively easy crossing of the River Neath (fig. 15). This point was protected by a fort which has been, on slight evidence, regarded as Nidum. The ridgeway Sarn Helen, which runs northwards parallel with the river, was no doubt used by the Romans as a link with their considerable fortress at Brecon.



IG. 15.—Some Factors which influenced the Sites of Swansea and Neath

Contours are shown at 100 feet, 400 feet and 800 feet.
reas of marsh and alluvium are shown; dotted areas represent blown sands, except near Neath, where the river-terrace is shown.

rom Neath westwards to the station at Maridunum, near armarthen, no certain traces of the road remain, but vidences of Roman habitation at Loughor suggest that the ide tidal estuary of that river was negotiated at this point, here it narrows considerably, and it has been assumed that his was the position of Leucarum. There was no station of

any importance west of Maridunum, if we except the small post called Castle Fleming in Pembrokeshire. If any connecting link between these places ever existed, no sign of it is known at present, although, on insufficient evidence, several old ways in the latter county are sometimes called Roman.

Finally, at Gelligaer a defensive work was built on what was probably a traditional route to the coastal plain from the neighbourhood of Brecon and beyond.

To what extent the Roman culture influenced the native Silures it is impossible to say. Possibly the coins which have been found at many places indicate trade contacts; similarly the appearance of Latin inscriptions side by side with the primitive Ogam markings may be evidence that the art of writing spread to some extent as a result of the occupation.

Post-Roman Settlements

The persistence of Christianity and of the arts associated with church-life, as well as evidence contained in the Welsh language itself—all these prove that the effects of Roman culture did not disappear so completely in Wales as they did in eastern Britain when the Romans departed in the fifth century. It is reasonably certain, however, that the Roman fortresses ceased to be inhabited, and with the possible exceptions of Caerleon and Caerwent, none remained to become the nucleus of a later community. It is also impossible to estimate the effect of the paved ways on movement in the succeeding centuries. The lowlands were covered by forests and probably were sparsely inhabited, for the greater number of the people of South Wales still lived almost entirely on the bare or lightly wooded uplands, tending their sheep and cattle and moving along traditional routes from pasture to pasture. The place-names 'Hafod' (summer home) and 'Hendre' (the old or permanent habitation) have been regarded as proof of some such seasonal movement. Remains of what may have been their palisaded enclosures are still visible on the plateau of north Glamorgan. The western or Pembrokeshire lowlands had from very early times received accretions of population

from overseas, and, especially after the withdrawal of the Romans, there is historical evidence that there was a large influx of Irish people into the area. They are said to have come peaceably and to have been allowed to settle without hindrance. It is possible that certain earthworks along the coast, the so-called 'cliff castles' and some defences which still bear the Irish place-name 'rath', may belong to this period.

A more important relation with Ireland followed the expansion of the Celtic church in the fifth and sixth centuries. The oldest communities in South Wales may with some certainty be said to date from this period, and during the centuries following many churches or cells were founded, sometimes on the sites of pagan sanctuaries. It would appear that these buildings were generally made of wood. None of them now exists, but it is likely that their sites remained sanctified, and that they have been occupied by churches to this day. This is of course hypothetical, but it is a fact that ancient stone crosses bearing inscriptions which show them to date back to this early period have been found by excavation near the foundations of many existing churches, notably at Llantwit Major and Llancarvan in Glamorgan, and at St. Davids and Penally in Pembrokeshire. It would thus seem that the sites of many villages were determined in very early times, for although no villages actually grew at those points until several centuries later, the ancient churches have usually become centres of settlements. None of these early churches is far from the sea, and it may be suggested that they were links in the close religious intercourse which existed between the Celtic lands and may have formed part of a pilgrim's way to Santiago da Compostella in north-west Spain. Prof. Fleure considers that St. Davids was probably the centre whither came 'ways from little landing places on either side of the headland which stands out so far towards the Irish coast'.

From the ninth century onwards the coast of South Wales was visited by bands of Scandinavian raiders. There is historical evidence of the damage they did to the monastic settlements at St. Davids and Llantwit Major, and on several

occasions they sacked the town of Caerleon. These piratical incursions continued for nearly two centuries, but then a change took place, and the raiders settled in a number of small areas along the seaboard. Evidence of this is found in the many Scandinavian place-names along the whole coast, but particularly in the neighbourhood of Milford Haven. Similar settlements had been taking place on the coast of Ireland, and it has been suggested that gradually a certain amount of trade grew up between the Irish and Welsh groups. Three towns were founded about this time in the western lowland, Fishguard on the north of the peninsula, Tenby in the south and Haverford in the centre, approached by the splendid waterway of Milford Haven. A special study of Scandinavian influences as they appear in Glamorgan has been made by Dr. D. R. Paterson, who writes—'The Danes and the Northmen were the leading merchants, and under their influence, villages arose at centres suitable for commerce. It is at least suggestive that Cardiff, Kenfig and Swansea—the three mediæval seaports of what is now the county of Glamorgan—contain Scandinavian elements in their names.' He finds evidence, too, of Nordic settlement along the old central road of the Vale of Glamorgan, but none on the plateau in the north of the county.

Thus apart from a very scattered native population on the plateau and in parts of the lowlands, pre-Norman settlement in South Wales appears to have consisted of no more than the Celtic churches, which were possibly the centres of small lay communities; the greater foundations of St. Davids and Llantwit Major; and a series of Scandinavian communities on or near the coast. They were in all cases the result of entries from the sea and bore practically no relation to the ancient east-west route.

Norman and Mediæval Settlements

The Norman occupation, like the Roman, was of a military character, and their method was to seize a strategic point and to fortify it. Ultimately every main sea entry into the South Wales coastal plain was commanded by a fortified post, or even a series of posts. Important fords were held

n the same way, and so were the points where ancient routes rom the wilder hill country came down to the plains. The arly type of castle was of wood, surmounting an earthen nound, surrounded as a rule by an enclosure or ' bailey '. The earthen mound often remains, and more than forty of hem have been identified in the county of Pembroke alone. In many cases they were evidently the centres around which he neighbouring village grew up at a later date.

In the later years of the eleventh, and in the two following enturies, a number of the more important of these castles vere replaced by carefully designed buildings of stone, like hose of Pembroke, Cardiff and Caerphilly. Such castles as hese became the centres of the more considerable com- nunities of South Wales before the Industrial Revolution. In this way there arose a number of walled towns, which in he first place were fortresses of the dominant baron, where ived men who fought when called upon to do so, but who, n peaceful times, usually had a craft of their own, as smiths, veavers, tanners, leather workers, and so forth. Thus as ime went on, and peace rather than war became the normal tate, each town developed a corporate spirit of its own, the nembers trading among themselves and even ultimately with he ' foreign ' Welshmen who came with increasing frequency o bring their products to the fairs. Pembroke, Tenby, Carmarthen, Swansea, Cowbridge and Cardiff were all walled owns of this type, and as the site of each was chosen for ts military value, we may with profit spend a little time in considering in greater detail the position of each of them, nd of some other towns, which although they may not have been encircled by walls, yet had a dominating castle, and became centres of trade in a similar way to those already nentioned.

Pembroke was the most important of a series of castles vhich were built to defend the sea entry of Milford Haven. ts precise position was on a tongue of land overlooking tributary arm of the Haven, and at the western end of an ncient ridgeway leading towards Tenby (fig. 16). At the ead of the main western arm of the waterway, the Western Cleddau, was situated Haverford, the earlier Scandinavian

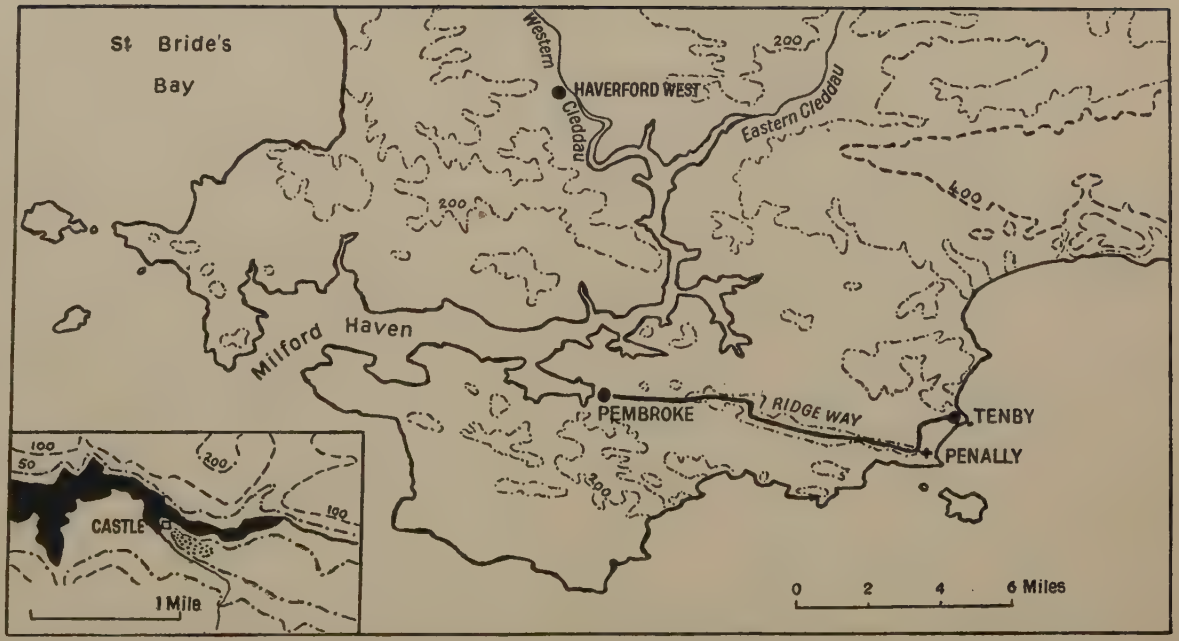


FIG. 16—Sites of the Walled Towns of Pembrokeshire, with the ancient ecclesiastical settlement of Penally

The small inset shows the site of Pembroke in greater detail.

ttlement which was also protected at a later date by a orman fortress. Tenby is situated at the base of a penin-ula which juts out in a south-easterly direction into the ristol Channel. The castle looks down from the headland to the little harbour on its sheltered north-eastern side. he town, at the end of the thirteenth century, was enclosed ithin walls, of which a considerable portion has survived the present day.

The site of Carmarthen is of particular interest, for it is tuated just where the Towy changes its course from west south. To this point comes an ancient route, Sarn Helen listinct, of course, from the route of the same name near eath), over the Teifi divide. Thus at this point four routes eet : one along the river valley, one from the west, more less along the track of the continuation of the Towy valley sturbance, the route from the sea, and lastly, that from e Teifi valley (fig. 17). The importance of the site had een noted by the Romans, and although the Norman castle d town, built on a ridge overlooking the river, did not incide in position with the Roman fort, the strategic purpose as identical. The bridge, which was built as one of the mmunications of the castle, was the last one between rmarthen and the sea, and thus the situation had the aracteristics necessary for the development of a port in ediæval times.

Kidwelly castle, commanding the entrance to the Gwen-aeth valley, gave rise to a settlement, and at various times ring the Middle Ages there was a thriving port at this int.

The Lordship of Gower, in Norman days, comprised all e land between the rivers Loughor and Tawe, south of the tle River Cathan. The castle which guarded the eastern trance of this domain was built at Swansea, where the ver Tawe, after flowing through a marshy flat, cuts a gorge rough the escarpment of the Pennant Sandstone before it ters the sea. The position guarded not only the entry m the sea, but also approach from either side of Kilvey ll (fig. 15). The trench-like upper valley of the River we was probably not used as a route at any time. Several

FIG. 17.—Some Factors which influenced the Site of Carmarthen

Contours are shown at 400 feet and 800 feet.

bsidiary castles guarded other sea entries into the peninsula Gower, and of these the most important was perhaps stremeue, the name which has become corrupted to Oyster-outh. The crossing of the River Loughor was held by a aller castle, built near the spot where several signs of oman occupation have been found, and where the broad tuary narrows before the river enters the Burry Estuary. Where the sea bites into the coastal plain in Swansea Bay, not only separates the Gower Peninsula from the Vale of amorgan, but at the same time forces the only possible east-st route northwards into the hill country. Consequently e road follows the eastern side of the bay from the south the River Neath (or Nedd), which flows, like the Tawe, rough an area of marshland in its lower course, and so the ossing is particularly difficult anywhere below the point ich the Romans had guarded (fig. 15). Thus it was here at the Norman castle of Neath was built, and the town ich grew around it became a small port, for reasons similar those which operated at Carmarthen.

Aberavon and Kenfig were two other interesting defences the eastern side of Swansea Bay, the former where a route me down from the plateau to the sea, the latter at the nction of the plateau, Vale and sea. Other settlements ich grew up along the border of the plateau and the vlands were Bridgend, Llantrisant and Caerphilly. In ch case they originated around a castle, the purpose of ich was to guard a route from the hill country to the le. We find these towns associated with trade at an early te.

Cowbridge, the central town of Bro Morganwg, grew up der the protection of the castle of St. Quintin, which guarded e gap made by the River Thaw in the ridge along which n the Via Julia Maritima. Its position in the centre of e of the most fertile areas caused it early to become a town considerable importance.

Cardiff castle was built on the actual site of the Roman tification, which defended the crossing of the River Taff. was the headquarters of the first Norman conqueror of amorgan. The mediæval town grew on the southern side

of the fortress at a point where the river approached closely to the edge of the river-terrace. No route came down the valley, the routes from the hill country being ridgeways in all cases, and the chief trade of Cardiff, when it later became a small port, was due to its situation on the main road from the Vale (fig. 14).

There was no important settlement at Newport in mediæval times. The River Usk flows outside of and parallel to the

FIG. 18.—Some Factors which influenced the Site of Newport
The road, following the crest of a ridge, crossed the river at the most suitable point.

northern and eastern rim of the coal-field, and has a course therefore which is somewhat the shape of a sickle. A few miles from the sea, its broad valley narrows where the river has cut through a ridge which runs east-west ; below this to the sea the river winds its way through low-lying country which was marsh until comparatively recent times. Thus the Roman road followed the ridge and crossed the river where the valley was narrow and the river bed suitable for a ford (fig. 18). When the Normans came they built a castle at the same point, but for some reason no community grew

ınd it of anything like the scale which we find in most of
e other cases noticed above.

Thus during mediæval times, settlements were founded in
rious ways in the coastal tracts of Wales. Gradually the
as of forest in these regions were reduced, and agriculture

. 19.—Some Factors which led to the Expansion of Newport after the Industrial Revolution

The area shaded represents land over 800 feet.

s fostered. During these times, therefore, the population
south Pembrokeshire, the Gower peninsula and the Vale
Glamorgan increased steadily and became greater than
t in the plateau country to the north, which remained
y thinly populated, chiefly by the descendants of the
-Roman inhabitants.

CHAPTER VI

THE BEGINNINGS OF TRADE

IN the primitive conditions prevalent in pre-Norman times there was very little trade or industry in the sense in which those terms are understood now. The people were almost entirely self-sufficing, and in any case they were so scattered and channels of movement were so infrequent that anything in the way of exchange was almost unnecessary and impossible except near the coasts.

When at length definite evidence of trade is available, the products were naturally those of pastoral industry,—wool woolfells and hides. Spinning and weaving were practised by the native Welsh from very early times, but a settlement of Flemings introduced into Pembrokeshire by Henry I in the earlier years of the twelfth century, brought improved methods of manufacture into the area. The existence of this intrusion has been doubted in many quarters, but it is now generally accepted as a fact that they settled between the two greater headwaters of Milford Haven, the Western and Eastern Cleddau.

In the early years of the thirteenth century Welsh woollen goods were sold as far afield as Boston in Lincolnshire, whither they had doubtless been conveyed by sea. Bristol, however was the chief English port concerned in the trade of South Wales. By the middle of the fourteenth century the woollen industry had become of considerable importance. The communities around the Norman castles had by this time become definitely established as towns, and in them were gathered craftsmen of many kinds, among them spinners and weavers. It is to these, and to the trade organization which they built up, that we may attribute the expansion in the

uth Wales woollen trade at this time. The most flourishing ntres were on the west, particularly at Carmarthen, but oath near Cardiff was also important, and here was intro-ced in this century one of the first fulling mills built in uth Wales. Cardiff was for a short time one of the two aple ports of the Welsh side of the Bristol Channel, but it ld the privilege only for a short time. When this was with-awn, its rival Carmarthen became and remained for some ne the sole staple port in all Wales.

Although chosen for military reasons the site of Carmarthen s particularly favourable for the growth of a port. It s a meeting-place of several routes, and a ' bridge-place ' brig-stowe, established at the lowest point downstream which a bridge could be built. This was at the head of the uary, near the limit of tidal rise and fall (fig. 17). Car-arthen thus became a natural economic centre and at the ne time the natural outlet for the whole district, sufficiently tant from the seaboard to be safe from the pirates who ested the Bristol Channel. Neath was similarly situated g. 15), but it did not develop because of the poverty of its terland, the thinly populated plateau of Blaenau Morganwg, th its forested and marshy valleys.

Most of the buying and selling took place at the fairs which re held periodically in each of the towns. This privilege l been among the first sought by the burgesses, as soon their community was constituted a borough. The fair s usually held near the church, in some cases (as at ngyfelach, near Swansea, even up to the eighteenth tury) actually in the churchyard, and the date corres-nded with that of the holy day of the patron saint of the rch.

The towns, with few exceptions, were in contact with the , and several of them developed a certain amount of coastal de. Milford, Haverford, Tenby and Carmarthen were ong the first to become important, and their small vessels e wool and woolfells chiefly to Bristol and Ireland. The os were made by the craftsmen of the towns, partly from l timber and partly from imported material. The men Pembrokeshire were also fishermen, and they brought

home fish from Irish waters. The foreign trade was almost entirely with France, and French vessels brought wine and salt, returning with wool, woolfells and hides.

In the earlier part of the Middle Ages coal does not appear in either coastal or foreign trade. One of the first references to coal is in a Swansea charter dated 1305, in which permission was given to the burgesses to dig pit-coal. For long after that date coal had no value as an article of commerce, and it was regarded as an inferior type of domestic fuel, in the same way as peat and brushwood.

The most definite change which took place between the beginning of the fourteenth and the end of the fifteenth century was a decrease in the proportion of wool exported and a corresponding increase in the amount of cloth. This is an indication of the development in the spinning and weaving industry in South Wales, particularly in Pembrokeshire and Carmarthenshire. At the end of the fifteenth century not only did Welsh cloth appear at the great cloth fair of St. Bartholomew in London, but it was taken as far as Spain and Portugal.

By Tudor times South Wales had attained a fair standard of development in several directions. The ancient weaving industry reached its maximum in the middle of the sixteenth century, with its chief centres in Pembrokeshire and at Carmarthen. By this time it had extended to North and Central Wales, where it grew so steadily that Pembrokeshire wool was exported to supply the demands of the industry. This fact was noted by George Owen, the historian of Pembrokeshire, who wrote at the end of the sixteenth century. The trade returns of this period show that, whereas in 1565 cloth represented two-thirds of the exports of that county, twenty years later wool took the first place and retained it for the remainder of the century. This decline in weaving was accompanied by an extension of sheep-rearing, and this was later followed by a decided increase in corn-growing, shown by the fact that corn rivalled wool in the exports of Pembrokeshire between 1593 and 1603.

Although Carmarthenshire shared in this decline of weaving there was not a corresponding increase in the corn produced

this district, the corn trade between Carmarthen and loucester and other creeks of the Severn being the most nportant part of the coastal trade. In the Vale of Glamorgan e land was devoted chiefly to stock-raising, and large quan-ies of butter, cheese and bacon were exported from Cardiff. certain quantity of barley, oats and rye was also produced, d there was not a shortage of cereals comparable with that Carmarthenshire. On the other hand, weaving was not rried on in the Vale to the same extent as in the counties rther west.

Coal became an article in the export trade of Pembroke-ire in the middle of the sixteenth century, when quantitites re carried to Ireland and to Cardiff. But it was not long fore the ports and creeks further east joined in the trade. 1566 coal was taken from Llanelly to Bideford, and from at time the ports of the Burry inlet exported coal to the ighbouring English coast. Swansea and Neath were but tle behind, and French vessels which had previously carried a regular trade with Pembrokeshire henceforth brought rgoes of wine and salt to these two ports, returning with al. Neath developed a copper-smelting industry in the later ars of the sixteenth century (see chapter VIII), and the porting of fuel was a necessary complement to this, for e vessels bringing copper ore returned to Cornwall with al.

The developments in South Wales which led to the Industrial volution are dealt with in succeeding chapters, but it may worth while noting at this point that French and Spanish n was imported into the area in the sixteenth century, and was not until much later that the Welsh product began to exported from Cardiff and Newport.

CHAPTER VII

AGRICULTURE

Physical Conditions

THE two physical factors of most importance to farmers are climate and soil, and the conditions described in chapter IV make South Wales a stock-raising rather than a grain-producing area. The moist condition of the atmosphere is favourable for the growth of rich grass, not only because of the amount of rainfall deposited throughout the seasons, but also owing to the low rate of evaporation which accompanies it. The mildness of the winter, particularly in the westerly portions, allows growth to continue later in the autumn and to recommence earlier in the spring than it does in eastern and northern Britain, and stock can be left out in the fields for all but a comparatively short period of every year. On the other hand the lower summer temperature delays the ripening of grain and makes it always a risky crop.

Differences in the depth and physical character of the soil are further determining factors. The soil covering of the high-land areas is thin, for the hard rocks weather slowly, and rainstorms and streams are continually bearing the rock-waste to a lower level and building up the alluvial flats in the valley bottoms of the larger rivers. In the lowlands the gradients are gentler so that a greater accumulation of weathered material results. But this is not the only source from which the soil of the lowlands has been derived. When the great ice-sheets of the Glacial Period disappeared they left behind them vast deposits of boulder clay, sand and gravel in varying proportions, which completely masked the

nderlying deposits. The surface of these has, in course of me, become soil, partly by natural agencies and partly as ie result of cultivation. In exposed situations the glacial eposits have since been removed but elsewhere they cover ie solid rocks, in places to a great depth, so that the latter ear no relation to the soil at the surface. The higher lands rely have such a covering, but platforms of glacial material ill persist on the sides of the upland valleys, and their flat- ess and good drainage make them valuable for cultivation areas where such fertile patches are infrequent. The glacial aterial has disappeared also from considerable portions of ie limestone areas fringing the coast of Gower, while in most arts of the Vale of Glamorgan there have never been extensive acial deposits, so that in these areas we find the char- teristically shallow and light soil associated with limestone ountry.

Earlier Conditions

The earliest information concerning agriculture in South ales is contained in the laws codified by Howell Dda in the iddle of the tenth century. These show that the people that time, and probably for some considerable period efore, were mainly pastoral and that their chief wealth was ttle. They reared sheep, pigs, horses, goats, bees, geese nd fowls in addition, but these were not their main concern. The people were divided into family groups, and every mily or ' gwely ' consisted of the great-grandfather and his escendants to the fourth generation. Each member received s inheritance direct from the ' gwely ', and this included azing rights over the common pasture together with the ght to cultivate a portion of the waste. This method of heritance came to be known as gavelkind and it is mentioned re because it seems to explain the fact that in the higher rts of South Wales we find the people living in isolated and hall farms rather than grouped in the villages which resulted om the manorial system, and which were commoner in the ains. As the cultivated patches were not enclosed the oduction of grain could never be successful, for the growing ops were at the mercy of wandering cattle and sheep in

search of food, but wheat, barley and oats are all mentioned in the laws of Howell.

The next account is contained in the *Description of Wales* by Giraldus Cambrensis, who wrote in the latter part of the twelfth century. He described the condition of the people after they had been driven from the more fertile lowlands by the Normans and English. He found them trained to war, eager and ready to give their lives in defence of their country and their liberty. Otherwise their mode of living had undergone no change, for, he says: 'Almost all the people live on the produce of their herds, with oats, milk, cheese and butter; eating flesh in larger proportions than bread. They pay no attention to commerce, shipping or manufactures.' . . . 'The greater part of their land is laid down to pasturage; little is cultivated, a very small quantity is ornamented with flowers and a still smaller is sown.' . . . 'They neither inhabit towns, villages nor castles, but live a solitary life in the woods.'

These conditions changed very slowly in the upland areas, and even when the days of wars and raiding had passed away, ancient customs and modes of life still persisted, so that the Welsheries retained their distinctive characteristics for many centuries. George Owen, writing of Pembrokeshire in the reign of Elizabeth, observed that there were 'greater breeds of cattle' in the Welsh, or northern portions of the country, than in the English parts, and that the people there cultivated oats in spite of the fact that their country was 'good and apt' for wheat. Gavelkind had been abolished but three-score years before he wrote, and, 'as a result that in many parts the ground is brought together by purchase and exchange, and hedges and inclosures are much increased so that now they fall to the tilling of winter wheat in greater abundance'.

The most complete changes took place in the lowlands. In Norman times they were for the most part forest-clad, and only very small portions of them—in the neighbourhood of castles and religious houses—were enclosed and cultivated. For several centuries the rearing of cattle and sheep was the main occupation of the sparse population, and wool was the chief item of commerce. The amount of grain grown was

arely enough to satisfy the needs of the communities themelves. Gradually the country was divided up into manors n the English plan, but the organization was never so comlete as it was on the plains of England, particularly in those anors bordering the Welsheries. These changes had the effect f increasing the area of the cultivated land, and the result as most apparent in the lowlands of Pembrokeshire and lamorgan. At the end of the sixteenth century, corn was exorted from the Pembrokeshire ports coastwise to North Wales nd also to Carmarthenshire. Both the latter county and lamorgan normally produced less than they consumed, and in udor times the import of corn was one of the prominent eatures of the trade between South Wales and the English reeks of the Severn. The Vale of Glamorgan, in spite of its onsiderable stretches of limestone pasture, did not produce ool on as large a scale as the counties further west. Its ief concern was dairy cattle and butter; cheese and bacon ere the most important items of its export trade in Elizaethan times. In 1578 Rice Merrick wrote that it was champion and open country without great store of nclosures'. A generation before, he says, there were fewer nclosures still. This seems to suggest that a very small roportion of the Vale was cultivated even at the end of the xteenth century.

Very few changes took place in the next two centuries, and griculture at the end of the eighteenth century in some parts South Wales was described as being as primitive as it ad been a thousand years before. Very little attention was ven to draining the land, and lime was the only manure ed, without regard to the actual needs of the soil. The me crops were grown again and again on the same ground ntil the soil was exhausted, and primitive ploughs were still awn by oxen. The cattle of the Vale of Glamorgan, howver, were famous, and the butter was as 'highly celebrated that of Epping Forest with London epicures'. The cheese as less appreciated by the English though popular among e Welsh. It was made of a mixture of ewe's and cow's lk and when it was fresh was 'exceedingly rich and high voured'.

With the idea of improving the standard of cultivation in Carmarthenshire and Glamorgan, the landowners themselves took over the management of their estates, and in some cases during the eighteenth century encouraged English farmers to settle on their land. The experiment was, on the whole, unsuccessful, for the men imported were generally of the wrong type, had no capital, and were ignorant of local conditions of soil and climate.

It was not until the closing years of the eighteenth and the early years of the nineteenth centuries that a remarkable development took place in the agriculture of the country. Agricultural Societies were formed and through them efforts were made to improve the methods of cultivation by draining, intelligent manuring, and by giving greater attention to the rotation of crops. The oldest Society was formed in Brecon-shire in 1755, and another was formed in Glamorgan fifteen years later. The construction of new roads and the improvement of old ones were not the least important of their activities. At this time the main road through Breconshire and Carmarthenshire to Fishguard and Milford Haven was constructed, and another through Cardiff, Cowbridge and Neath to Swansea. A number of transverse roads running roughly north-south were made joining the main east-west routes.

These, taken in conjunction with those constructed by the proprietors of the ironworks, represented a network which was a powerful stimulus both to industrial and to agricultural development.

An important feature of this development was the abandonment of cultivation in open fields and the enclosure of arable land. This led in general to the growth of large estates and the extinction of the yeoman farmer. Bad harvests and the disturbances resulting from the Napoleonic wars forced up the price of wheat in the early years of the nineteenth century, and this caused a very large extension of cultivated land—even upland sheepwalks being ploughed. Land values and rents soared to two or even three times their normal levels, so that, when the slump came at the end of the wars, there was widespread depression. Corn Laws, intended to main-

ain the high price of wheat, gave rise to grave distress among he poorer classes of the community in the first half of the ineteenth century, and this in great part occasioned the Rebecca ' riots in South Wales, in which attacks were made n the toll-gates on the main roads, partly as a result of the ritation caused thereby, but mainly to draw attention to he general distress caused by high rents, rates and taxes. he years following the repeal of the Corn Laws saw a great mprovement in agricultural prosperity. The increasing ndustrial population created such a demand for food that here was but little diminution of the acreage under wheat, n spite of the increasing importation of food-stuffs. Since bout 1870, however, there has been a constant flow of foreign heat into British markets, a result of the introduction of teamers and the construction of railways, so that the British armer now finds himself in competition with wheat-growers ll over the world, who, with the advantages of virgin soil nd superior climate, are able to undersell him in the home narket. The result has been a decline in the acreage under heat during the last sixty years—with the exception of a emporary increase in the years of the Great War—and a orresponding extension of the pasturage.

The following figures indicate the changes which took lace in the agriculture of Breconshire :

Year.	Permanent Pasture.	Wheat.	Other Corn Crops.	Cattle.	Sheep.
1868	115	11	25	34	390
1871	?	10	26	34	402
1881	140	7	23	35	330
1892	150	4	20	42	461

[The figures represent 1000's of acres and of animals.]

The decrease in the whole of Wales in the wheat acreage as about 25 per cent over the same period, but the farmers f Breconshire and Glamorgan at that period had special ifficulties in obtaining cheap labour, owing to the neighbour-ood of the developing industries on the coal-field.

Present Conditions

The following table shows the distribution of the various types of farming land in 1927. The figures in brackets are the corresponding ones for 1918 and are given for the purpose of comparison, but it must be noted that these were the result of special conditions due to the Great War.

County.	Total Acreage.	Rough Grazing.	Permanent Grass.	Arable.
Brecon	466.	218 (248)	141 (145)	35 (50)
Monmouth . . .	347	52 (32)	184 (180)	29 (53)
Glamorgan . . .	516	139 (123)	182 (185)	42 (69)
Carmarthen . .	586	99 (76)	354 (324)	56 (110)
Pembroke . . .	392	66 (47)	208 (181)	82 (120)
Total . . .	2,307	574 (526)	1,069 (1,015)	244 (402)

[The figures represent 1,000's of acres.]

The above figures show that a quarter of the acreage available for farming is rough pasture suitable only for the grazing of sheep; about one-half is permanent pasture, and about one-tenth only is arable. The rough grazing land is made up of the high moorlands of Epynt, Brecon Beacons, Fforest Fawr, the plateau of north Glamorgan and Mynydd Precelli, together with the Carboniferous Limestone and Old Red Sandstone areas of the Vale of Glamorgan and Gower. The permanent pasture includes the richer meadows of the lowlands and the alluvial flats along the river valleys and the shore of the Severn.

The extent of pasture has expanded during the past ten years, mainly at the expense of the arable land. As we have noted above, it is a movement which has been going on for a long time—at least sixty years—but the larger area cultivated during the later years of the War was the result of a special effort to increase home produce during that period. Since its conclusion, geographical and economic influences once more have operated in favour of stock-raising and against the production of grain.

The following table shows the number of live stock in June 927, with the 1918 figures in brackets (each in thousands).

County.	Sheep.	Dairy Cattle.	Total Cattle.	Total Horses.
recon	539 (501)	15 (15)	40 (42)	11 (12)
onmouth . . .	222 (213)	19 (18)	52 (54)	11 (15)
lamorgan . . .	320 (281)	27 (25)	59 (60)	14 (18)
armarthen . . .	309 (275)	55 (51)	120 (124)	18 (26)
embroke	146 (133)	34 (31)	102 (95)	14 (17)

The wide extent of its uplands makes Breconshire the most nportant sheep-rearing county in Wales, with a stock of ıore than half a million.

Comparison with the table on p. 71 will show a continuous ıcrease in each decade, with the exception of the disastrous ear 1881 when many thousands of animals all over the ountry were lost through disease. The breed most common ı Breconshire is derived from the small mountain type which more profitable for its flesh than for its fleece. The native adnor breed has been crossed with the larger Shropshire own sheep, increasing the size of the animal and the value f its fleece. The strain is more pronounced towards the astern border. Glamorgan has fewer sheep, and is second ı order among the southern counties of Wales. They are, owever, not all of the same type; large numbers of the ountain breed pasture on the plateau in summer, but the emainder are of the larger lowland type. These are mainly nported breeds—Leicesters, Cotswolds and several varieties f the Down sheep—and are found chiefly on the limestone of ıe Vale and Gower.

The farms on the heavier and wetter soils are less suitable r sheep-breeding owing to the presence of a parasite which tacks and kills the animals. Numbers of sheep are imported these areas each winter from outlying districts for fattening spring. Recent research has, however, produced a remedy r the disease of liver-fluke which may increase sheep-rearing areas where it is now impossible.

In Carmarthenshire, sheep are reared in the largest numbers

in the upland areas in the north of the county, that is, on the western ends of Fforest Fawr and Epynt, and on the high pastures of the Towy-Teifi divide. In view of the pre-eminence of Pembrokeshire as a wool-producer in the Middle Ages it is interesting to note that, with the exception of Flint, it now rears fewer sheep than any other county.

The greatest area of lowland pasture in South Wales is in Carmarthenshire, and it includes the fertile Vale of Towy. The Vale of Glamorgan and Gower yield in pasture rather more than half that area, and so do each of the counties of Monmouth and Pembroke. Cattle-rearing is the most important occupation in these regions, and more attention is given to milk production than to the fattening of the animals for beef. Butter is produced in large quantities in Pembrokeshire and Carmarthenshire, which in this respect have overtaken Glamorgan, where the famous old breed of dark brown cattle has died out.

The making of cheese is on a much smaller scale than used to be the case. One reason advanced for this decline is the difficulty of obtaining dairymaids with the requisite skill. The only centres of cheese production are Carmarthen and Brecon—a Stilton variety being produced at the latter. The old Welsh cheese is no longer made, nor is the famous Caerphilly cheese now manufactured at the place which gave it its name.

The most striking development of recent years has been the sale of ' liquid ' milk, which is more profitable than either cheese or butter making. It started in a general way in the districts near areas of denser population, but now it has grown into a regular industry with an organization of its own. The most important areas are Pembrokeshire and Carmarthenshire, where the Farmers' Co-operative Societies have established creameries and milk-collecting centres in various parts of the counties. Twenty years ago there was a marked tendency for farms near the railway to concentrate on milk production, but since the coming of motor road transport, farms distant from the railroad have taken it up.

The farmers have erected small platforms at many points on the roadside to which they bring their churns, and thence

notor lorries take them to the nearest creamery or railway tation. Large quantities are exported every day, not only o the town of South Wales, but even to London, where it s said a very large proportion of the owners of milk-walks re Pembrokeshire men. Swansea obtains its milk mainly rom these areas, and only to a small extent from Gower. The Vale of Glamorgan supplies Cardiff and the eastern alleys of the coal-field. The valley of the Usk is largely iven over to dairy-farming, and so is the low-lying alluvial lain between Newport and the Severn.

Horses are reared for farm purposes in each of the counties. ormerly there was a considerable trade in ponies for the ines, but this has recently decreased.

Pembrokeshire is by far the most important arable county n South Wales, including as it does a third of all the ploughed nd in the area. Rather more than one-third of it is devoted o the growing of grain, chiefly barley and oats.

The following table shows the areas under cultivated grass nd cereals in 1927, with the figures for 1918 added in brackets.

County.	Wheat.	Barley.	Oats.	Cultivated Grasses.		
				For Hay.	Not for Hay.	Total.
recon . . .	1 (6)	2 (5)	10 (21)	7	10	17 (11)
onmouth . .	4 (17)	1 (3)	6 (16)	7	4	11 (6)
lamorgan . .	3 (12)	3 (7)	9 (25)	12	5	17 (12)
armarthen . .	2 (15)	4 (12)	18 (42)	11	6	17 (18)
embroke . .	1 (6)	11 (23)	21 (48)	22	13	35 (25)

[The figures are in thousands of acres.]

The amount of wheat grown is insignificant, only enough eing grown for the farmers' own convenience. We may ote, however, that the cultivation increases eastwards along ne plain with the higher summer temperatures. It is to be oted that barley increases in the opposite direction, so that embrokeshire produces more barley than any other Welsh ounty. Only a small proportion of it is suitable for malt, nd most is used to feed the stock. The most useful cereal, nd the one best suited to the climate, is oats, which is there-

fore cultivated on a larger scale than the other grains, particularly in the western counties. In Pembrokeshire a very large proportion of the arable land is utilized for the production of clover and other rotation grasses for feeding the animals.

Carmarthenshire is the most important poultry-rearing county in Wales, being especially known for its turkeys. Glamorgan is the largest producer of geese.

Market gardening is important only in the neighbourhood of the larger towns, chiefly in the eastern parts of the Vale of Glamorgan and Gower, and the produce is mainly sold in the markets of Cardiff and Swansea. The area cultivated is very small in relation to the demands of the urban populations, and large quantities are imported at the ports—Cardiff dealing with more potatoes than any other port in Britain. A scheme is on foot to utilize the mild winter of Pembrokeshire in the cultivation of early green vegetables for the London market.

Monmouthshire and Breconshire are the only counties with an important crop of fruit, the acreage of orchards in the former county being exactly half of that in the whole of Wales.

CHAPTER VIII

THE COPPER INDUSTRY AND RELATED INDUSTRIES

THE first important industrial development in the South Wales coal-field was due to the smelting of imported lead, silver and copper ores, and until me fifty years ago the production of copper was the most nportant influence in the growth of the districts around vansea and Neath. Thus, although it is no longer the main dustry of the area, its earlier importance entitles it to rticular consideration.

The Early Development of the Copper Trade

It had been the practice in early times to smelt any ore ar the mine where it was worked, and to use the local timber r the necessary charcoal. The life of a mine depended to large extent on the possibility of obtaining near at hand a fficient supply of fuel, and as this was used up at a faster te than it could be renewed, timber became more and more fficult to obtain. Such difficulties as these caused the copper iners of Trewoorth in Cornwall to build a smelting house at eath in the year 1584. Their mine was near the sea, and eath, as well as being on a navigable river, was in the middle a well-forested area and possessed abundance of 'sea-le' (fig. 15). It was possible therefore to transport the e all the way by sea in small coastal sailing vessels. This a very early instance of a practice which became the usual e at a later date, that of transporting the ore to the fuel. The exact site of this early works is not certain, but it was obably on the bank of the river Neath, at the point where tributary the Clydach enters it, not far from the Abbey

of Neath, then but recently abandoned and in natural surroundings of great beauty.

At first 'sea-cole' was used experimentally with the charcoal in the process of smelting, '8 or 9 seks of charcoles and 3 horslods of sea-coles' to smelt 24 cwt. of ore, and so the timbered lands near Neath were gradually cleared, and increasing quantities of coal were mined.

After the ore had been roasted it was washed to remove unwanted sulphur, vitriol and other impurities, and finally smelted with further supplies of charcoal and coal. This process involved the giving off of great volumes of a particularly disagreeable smoke, which, although not definitely harmful to human beings, was deadly to vegetation, and probably in a short time disfigured the whole of the area in the vicinity of the smelting works.

Apart from this disfiguration of the countryside, the new industry did good to the market and burgesses of Neath by increasing the demand for coal; not only were considerable amounts required for the actual smelting but every ship returned to Cornwall loaded with it. Subsequently the ancient rights of the burgesses, whereby each was entitled to dig his own pit on the common lands of the town, were leased to a gentleman of the district, and thereafter the working of the local seams was in his hands.

This introduction of the copper smelting was followed a hundred years or so afterwards by another similar enterprise, the smelting of lead, the extraction of silver and the manufacture of red lead, a mile or so south of Neath and on the eastern side of the river, The ores came to this works from the mines of Plynlimmon by sea from Aberdovey, to which port they had been conveyed partly by pack-horse and partly by boat.

Thus Neath at the end of the seventeenth century was a busy industrial centre, importing non-ferrous ores by sea, extracting the lead, silver and copper from them, mining and exporting its coal. No other area in South Wales at this date utilized its coal in this way for the refinement or smelting of imported ores.

Swansea, however, presently developed in a similar manner.

or some years that port had had a considerable trade by sea, ainly coastwise, but to some extent with France, and was ven then a town of greater importance than Neath. The asons for this superiority were at least twofold; it stood the entrance to a large agricultural area, Gower, and was ie focus of its trade, while its harbour was sheltered on the est and south-west by Mumbles Head. Neath's hinterland as high moorland, forest and marsh, and the entrance to s harbour was a difficult channel on the coast facing the revailing winds (fig. 15). At this date Swansea was the ost important of the Welsh ports on the Bristol Channel. At the beginning of the eighteenth century the first copper orks in the Swansea area was built at Landore, some two iles up the River Tawe, where the river hugs the western de of the valley, with a marshy flat half a mile wide to the st (fig. 20). The suffocating and devastating effects of the mes had been noted, and the inhabitants insisted that the orks be placed at some distance from the town. The selected te was suitable in all respects, for the destructive fumes were sually carried by the prevailing winds across a tract of eless marsh to the east, the coal was near at hand and the oats bringing ore were able to ascend to that part of the ver. Within a few years there was a line of similar works in e area, and a new village was built just north of them, and t of the reach of the fumes, by one of the copper masters, obert Morris, and was called Morriston. A group of works as also erected lower down the river, and on the east side the Tawe gorge (fig. 19). At this point a suitable quay as built for taking in the ore and for exporting coal from e coal-workings further east. At first, pack-horses were ed for transport, but a horse tramway was later laid down, is in turn being superseded by a canal before the end of the ntury.

Cornwall remained the chief source of ore during the ntury, but considerable quantities also came from Anglesey d Ireland. The works on the east of the Tawe were mainly ncerned with Welsh ore, which represented the poorer ore om the Parys mine in Anglesey, the richer material being elted at the source. At Swansea, a mixture of ores was

possible, and it was found that some impurities in the mixture acted as fluxes for others, thus making profitable the smelting of the inferior grades of ore.

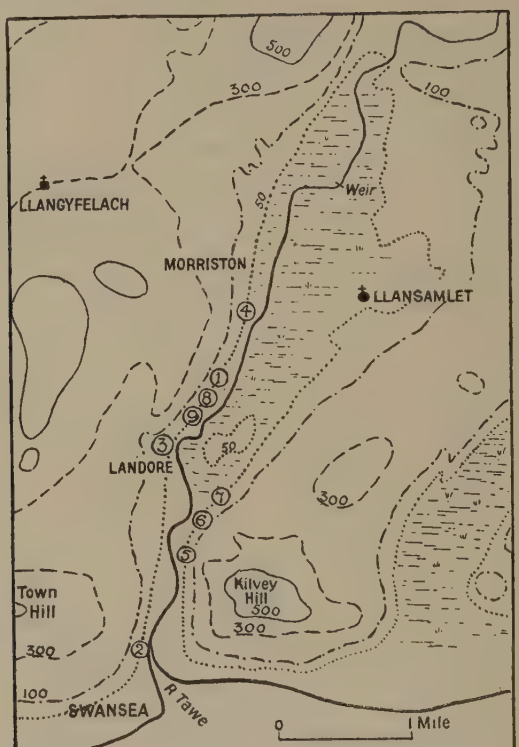


FIG. 20.—Map showing the Positions of the earlier Copper Works near Swansea

The works are numbered in the order in which they were built.

THE EXPANSION OF THE COPPER TRADE

Up to the beginning of the nineteenth century the only copper works in South Wales, except those near Swansea and Neath, were in the ancient borough of Aberavon, where they were built shortly after the first works at Swansea. Early in the nineteenth century, however, there was a considerable

xpansion in the trade, and works were built at Llanelly, hen a little port on the north of Burry inlet, at Loughor, a ttle further east on the same inlet, and at Penclawdd, n its southern shore, where a lead-smelting works was onverted. The two last-mentioned works were short-lived, ut the Llanelly works became an important factor in the evelopment of that district. In Swansea also a further orks was built at the Hafod by John Vivian, which grew be one of the most important centres of the copper trade. In 1828 the first foreign ore was imported, and henceforth creasing amounts of this richer material were added to the nports from British—mainly Cornish and Irish—sources. n the first half of the century Chile and Cuba supplied most the foreign ore, and as a result the vessels entering the port Swansea became not only larger but more seaworthy in ery respect, for some of them had to withstand the stormy assage around Cape Horn, on a voyage—out and home—six months. These ships were roughly ten tiines the size those which carried on the coastwise trade with Cornwall, hich still represented the bulk of the trade of the port. In 45, out of 4,569 vessels entering the port, 4,132 were engaged coastwise trade. This fact influenced the design of the st dock on the Tawe, opened in 1852. In the Tawe gorge e river sweeps round in a big curve to its right bank ; a w channel was cut as a chord across this, the river diverted o it, and the old river bed converted into a dock or ' float ' g. 28). By this arrangement the Cornish boats could still ss upstream to the copper works, and the larger ocean-ing vessels unloaded in the new ' North ' dock.

As it happened, before this date the two main sources of e, Cuba and Cornwall, had reached their zenith and began decline. The total trade, however, continued to expand ing to an increase in the imports from Chile, and to the velopment of new sources, among them Australia, Canada l the United States. The copper-smelting trade in the ansea district was at its greatest in 1866, and the first ication of its decline was that the Chilians and Australians, smelting their best ores near the mines, were able to under- the British smelters. Swansea, however, continued for

many years to be the most important copper-smelting district in the world. At about this date there were 24 copper-smelting works in the British Isles, and of these 8 were at Swansea, 2 at Aberavon, and 2 in the Llanelly district; this pre-eminence continued until about 1888, when the value of the copper smelted was about 1½ millions sterling. From this point onwards there has been a steady decline in the industry.

The Decline of the Copper Trade

In the early days, when the world's supply of copper was obtained mainly from the comparatively poor ores of Cornwall, the difficulty of smelting without mixing the ores caused the concentration of smelting houses in Swansea. As the mineral regions of the world became more fully known, and deposits of richer ores were discovered, Swansea at first reaped the benefit (on account of industrial inertia), but the practice of smelting at the mines grew, particularly where fuel could be obtained near at hand. The chief competitor was the United States, for deposits of copper of unexampled richness were being developed on the southern shores of Lake Superior. In spite of this, Swansea continued to be the centre of the world's copper trade until the late 80's. From that time the import of copper ores decreased and very gradually copper smelting became less and less the main industry of Swansea, partly owing to the decline of the industry locally on account of world causes, and partly because of the increase in the importance of the manufacture of tin-plates in the area, and in the export of coal.

At the present time there is no copper smelting in the region, but the refining of roughly smelted copper (so-called 'blister-copper') is carried on. The refined material is made into ingots, sheets, bars, fire-boxes for locomotives and so on. Copper sulphate is also produced and is mainly exported to France and the Mediterranean for use in the spraying of vineyards.

Other Non-Ferrous Metal Industries

Lead and silver ores are still smelted in the region, but their importance has never approached that reached by the copper

smelting industry. The district, however, has been the centre of the production of commercial zinc or spelter for many years, and as the copper trade declined, several works were converted to this purpose. Since 1888 the works in the Swansea area have produced annually 95 per cent of the total British production. Until a few years ago zinc blende (zinc sulphide) and calamine (zinc carbonate) were used locally. The calamine was imported mainly from Greece, Sardinia and north Africa, and was rich in zinc, while the blende came coastwise from north Wales. Calamine is difficult to obtain, and owing to the difficulty of general trade conditions the industry has suffered hard times ever since the Great War. Fortunately, a purchase of Australian concentrates by the Government made it possible for the works to continue, although the concentrates were more expensive to refine. A considerable amount of sulphuric acid is obtained as a by-product, however, when the necessary plant is installed.

The most important centre for the refinement of nickel in the British Isles is at Clydach, a few miles north of Swansea.

Chemical Industries

When the copper-smelting industry was in full swing sulphuric acid was obtained in large quantities from the destructive copper smoke, which was mainly sulphuric and sulphurous acid. It was long before a successful method of trapping it was devised, and in 1857 it was estimated that an income of £450,000 was being lost annually; it was not until 1866 that a suitable method was adopted. This was the beginning of a very important chemical industry, and in twenty years twenty works were manufacturing sulphuric, alkalic and muriatic acids, and the sulphates of soda, copper and zinc, as well as many other chemicals. Much of this chemical industry declined with the copper trade, but the demand for sulphuric acid by the tin-plate works is sufficient to maintain a considerable trade. An increasing amount of this acid is being rendered available by the acid by-product plants in the spelter works. Copper sulphate is produced as a by-product in the nickel industry.

Chemical manures, chiefly basic slag and superphosphate, are similarly produced by the steel industry, and a considerable manufacture of disinfectants and antiseptics is being carried on at Briton Ferry.

CHAPTER IX

THE IRON AND STEEL INDUSTRIES

IT may perhaps appear strange that the iron and steel industries are dealt with before the coal industry, which employs a much greater number of workers, but although he iron industry is not the most important in South Wales t has exerted a great influence on the development of the oal and other trades. Iron was probably worked in South Wales in very early days, long before coal was mined. Indeed, t some stages when iron ores were worked in association vith coal beds, the coal was thrown on one side. Later, luring the eighteenth century, South Wales began to pass hrough those changes which converted a sparsely populated gricultural region into a busy industrial area, changes which re spoken of as the Industrial Revolution, and at that time was the iron trade, more than anything else, which led to he changes. The iron produced was to be sent all over Britain, and to many other countries, and as the industry eveloped it needed improved communications—roads, anals, railways, docks; when these were provided for the on industry other industries made use of them and were hus enabled to develop. Of these later industries the coal ade is of course by far the most important, but it is doubtful ow far the rapid growth of this industry would have been ossible if it had not been for the transport facilities already rovided by iron.

The South Wales iron trade grew up slowly from small eginnings, and progressed because of the abundance of local ore, ogether with the supplies of fuel and other materials, such as imestone, which are needed in smelting. The iron-ores found South Wales are of two kinds, hæmatites and clay ironstones.

Iron Ores of South Wales

The hæmatite ores are found in the Carboniferous Limestone, chiefly in the area north-west of Cardiff; they have been extensively worked in Garth Wood, near Tongwynlais, and are still mined at Llanharry, near Llantrisant. A small mass of the ore has also been worked near Mumbles Head, in Gower, while similar ores are now worked in the Forest of Dean. The hæmatite ore is relatively rich, sometimes containing over 50 per cent of iron; but the ore is very irregular in its distribution, occurring in veins which are discontinuous and in masses of uncertain extent.

The clay ironstones occur in the Coal Measures. They are chiefly found in the Lower Coal Series, but occur also in the Upper Coal Series. They frequently form beds in the shales above coal seams. These beds of ironstone or 'mine' are generally thin, usually not more than a few inches in thickness, and each bed may consist of isolated nodules up to about a foot in diameter ('balls') or of a continuous thin layer ('pin'). Often several such beds occur one above the other, separated by thin layers of shale, giving perhaps a total thickness of 6 or 9 inches of ironstone in 3 feet of shale. In these ores the iron compound may be considered as impregnating the clay or shale, and the ore is thus very impure. Some good nodules contain up to 36 per cent of iron, but others are very much more 'lean'. These ores also contain quantities of such impurities as phosphorus and sulphur.

In the development of the iron industry of South Wales the clay ironstones have been much more important than the hæmatites, and the localization of the industry has been largely influenced by these ores. They underlie the whole of the coal-field, but have only been worked to any considerable extent around their outcrops, especially in the north of the coal-field. The ores are generally thicker in the west than in the east, but on the other hand, those in the east are usually the richer, and have been more extensively used.

The Early Iron Trade

These native ores of South Wales have been worked intermittently from very early times. It is almost certain that

hey were worked in some places as early as Roman times. From that time onwards for many centuries very small quantities of iron were made, and iron implements must have been quite scarce at some times. Thus we read of an anvil being borrowed in Elizabeth's reign by a Thomas Sulley of St. Athan's, Glamorgan, from the west of England. During these early centuries, however, iron working was carried out in many places. It is possible that at times an itinerant smelter visited the villages and made sufficient iron to supply the needs of local farmers, using the nearest available supplies of ore and making a lump or ' bloom ' of iron by means of charcoal at a hearth or ' bloomery '. Traces of such hearths are known in many parts of South Wales, their positions being marked by heaps of slag or ' cinders ', from which only a part of the iron had been extracted by the primitive methods of the ancient smelters, so that in some cases it has been profitable to re-smelt them in later years. These heaps often represent places where apparently no more than 1 ton of iron was made. The bloomeries are generally situated on exposed hills, where advantage could be taken of the wind for assisting the blast, which was provided by means of hand bellows.

At a later stage iron smelting was carried out on a larger scale, for instance by the monks of Margam Abbey, and iron furnaces were erected in several localities, as at Caerphilly, in the fourteenth century. In the sixteenth century several furnaces were in existence. These were situated in various parts of South Wales, near Aberdare, at Merthyr, at Radyr (near Cardiff), at Pontypool, and perhaps also in Carmarthenshire. The larger furnaces at that time were about 10 feet in height. They were often built under a hill so that they could be more easily filled, and they were generally situated near a stream which could be utilized for working the bellows. Charcoal was used in smelting, the wood obtained by clearing an acre of forest being sufficient to produce only 3 tons of iron. The larger furnaces in Elizabeth's reign were capable of making about 20 tons of iron per week, and it will thus be seen that the woodlands suffered greatly, so that laws were enacted in that reign to prevent the removal of timber from certain areas.

During the next century there was very little change in the state of the iron trade in Wales. The few ironworks employed comparatively small numbers of men, and South Wales was still primarily an agricultural area. The iron manufacturers supplied cannon and shot to fight the Spanish Armada, and at least one of them was suspected of supplying the Armada also, while later, supplies were made for Cromwell's army. Until this time, the chief iron district in Britain was the Weald of Kent and Sussex, where both iron ores and timber were available. As the Weald became deforested, however, the iron manufacturers were compelled to seek new fields for their activities. Many moved to Staffordshire and the adjoining counties, but some journeyed into Wales and took part in the building of the iron industry. They found a region of which much was still densely wooded, and their only doubt was whether the supply of ore would be adequate; their fears were not justified, for although the wood has long been used up, the greater part of the ore is still unworked. During this period much of the wooded country within the coal-field borders became deforested; many of the place-names, especially in the eastern part of South Wales, testify to the former extent of the forests. By 1740 the iron trade had greatly dwindled in South Wales, owing to the increasing scarcity of wood for making charcoal, and at that time not more than seven furnaces were in work in the whole of the area.

Practically all these furnaces were using the nodular ores from the Coal Measures. The ore was taken on the backs of ponies or mules often for miles to furnaces sometimes as far away as Brecon, beyond the limits of the coal-field, where plentiful supplies of fuel could be obtained. At first the clay ironstones were gathered from the beds of streams which crossed their outcrop, the nodules having been separated from the shale by weathering, and the shaley material having been carried away by the stream. In some places boys were employed to collect the nodules. As these supplies were exhausted, the iron workers hurried on the natural processes by resorting to 'scouring'; a pond was formed by damming up a stream, the water after a time being allowed

o rush away suddenly, leaving behind the nodules. By this process wide areas of land were ruined. Traces of the early working of ores by scouring are to be seen in many parts of the coal-field at the present time, and especially along its north-eastern border. Later the ores were worked by slants and levels, in many places along with the coal.

At an early stage in the development of the iron industry, therefore, several factors, such as the necessity of obtaining water-power and the ease of getting the ores, were tending to bring the industry into the valleys, and thus to initiate that valleyward movement of population which has been continued in South Wales throughout the Industrial Revolution.

The Growth of the Iron Trade

The iron trade of South Wales entered into a period of remarkable expansion about the middle of the eighteenth century. This period was marked by the arrival in the area of several ironmasters from Staffordshire and the north of England, whose skill and experience led to the building up of some great ironworks. At about this time, too, the use of coal (or coke) in smelting came to be more general: its utility had been demonstrated a century earlier by one Dud Dudley of Worcestershire, but many years elapsed before the process was adopted. Before the end of the century scarcely any charcoal was used in smelting, and the industry tended therefore to become more concentrated, since the ore and the fuel could now be worked in the same neighbourhood. The more distant works outside the coalfield were gradually abandoned.

The largest new works at this period were in the north-eastern part of the coal-field. Their situation was partly determined by the structure of the Coal Measures, the gentle dip of the rocks on the north of the coal-field giving rise to a much greater breadth of country over which the rocks occur at the surface than on the south (fig. 4): owing to the gentler dip also both iron ores and coal were more readily mined on the north than on the south. Since the richer ores occurred in the eastern part of the coal-field, which had also

the advantages of closer proximity to the markets of England, the eastern part became more important than the west. Thus one set of factors tended to the development of the north rather than the south, another to the development of the east rather than the west, so that the greatest development occurred in the north-eastern part of the coal-field. Near to that area also are outcrops of limestone, needed in smelting, and of refractory materials, the siliceous rocks of the Millstone Grit, required for the making of furnace linings.

It was in this part of the coal-field that the settlers from the north built their ironworks. Chief among them may be mentioned John Guest from Brosely, who in 1758 began the development of the Dowlais works, founded shortly before that date by one Lewis of the Fan, and Anthony Bacon of Whitehaven, who founded Cyfarthfa works in 1765. At first charcoal was used in smelting, and some of the workmen of Cyfarthfa spent three days of each week in cutting wood, but gradually the use of coal became universal. About this time also other works were erected in the country near Merthyr and Aberdare, and later there were developments in neighbouring valleys, at Ebbw Vale, Rhymney and Blaenavon, giving rise to a belt of ironworks which extended roughly east and west along the north-eastern margin of the coal-field, following the outcrop of the Lower Coal Series. Further west again, other works had been established, as at Ystalyfera and Ystradgynlais, where plenty of ore was available, but where the coal, being anthracitic, was not suitable for smelting. It was not possible to use anthracite for that purpose until about 1838, when Crane of Ynyscedwin and others devised methods of smelting with anthracite. The chief developments of ironworks in that area and in the areas further west, in Carmarthenshire and Pembrokeshire, took place between that date and 1850.

In the eighteenth century, at the time when the early developments in the iron industry were taking place, the communications within the plateau region of South Wales were scarcely any better than they were centuries before. There were scarcely any roads, other than tracks over the hills. Iron ore was carried in sacks by mules and ponies

long these ancient tracks, each animal carrying something ver a hundredweight, and one boy or woman accompanying ach three or four animals. Although labour costs were then ery low and money had not its present value, the transport f iron over the distance of practically twenty miles from he works to the sea generally cost as much as twelve shillings er ton. From Merthyr and the eastern furnaces, the iron as chiefly sent to Cardiff and Newport for export, from Hirwain and Ystradgynlais, to Neath and Swansea.

The increase in the iron trade led to the need for better ransport facilities, and Anthony Bacon of Cyfarthfa took teps which led to the construction of a road from Merthyr o Cardiff, in 1767. This road, the first to be constructed long a valley within the coal-field, made it possible to convey he iron from the Merthyr works in large wagons drawn by orses. Later on, near the end of the century, there was further development in the means of transport, canals eing constructed from the industrial areas to the coast at Newport, Cardiff, Neath and Swansea. In several places ail-roads or tram-roads connected the canals and the works, agons being drawn by horses along flat rails. By 1811 early 150 miles of such rail-roads were in existence in South Vales, all of which had been constructed during the preceding wenty years. Most of these tram-roads were not more than few miles in length, but in 1812 a rail-road was made from irhowy to Newport, on which ran large wagons carrying tons (fig. 25). These vast improvements in means of ransport made it possible for the iron trade to expand rapidly uring these years.

At about this time the iron trade was further helped and timulated by the improvements of the steam engine by Vatt, Trevethick, and others, and engines were used to upply the blast for the furnaces. Larger furnaces were onstructed, those in use in 1800 being about 50 feet high. he output of iron from South Wales thus increased rapidly. n 1800 the total output of iron was a little over 2,000 tons, ut by 1820 the ninety furnaces in South Wales produced 50,000 tons, which was raised to 220,000 tons by 1825.

Shortly after this, the era of railway construction further

stimulated the industry, first by making possible still greater improvements in the means of transport, and secondly by creating such a demand for iron as had never been experienced before. It may be suggested that the growth of the iron industry helped on the development of the steam railway; for after the construction of the tram-roads it was but a short step to apply steam power, and in this application Trevethick and others connected with the iron industry in South Wales played a prominent part. Numerous experiments were made in the iron-making districts with various steam engines designed for use on the tram-roads. In 1804 an engine drew 10 tons of iron for 9 miles at 5 miles an hour, and caused no little wonder because it was unnecessary for it to stop during that journey to take up water. By 1829 a locomotive constructed by Stephenson was making regular journeys between Newport and Tredegar. With the building of railways both in Britain and abroad during the ensuing decades, the iron trade entered upon a time of great activity. In 1835 orders for over 200,000 tons of rails were placed in Aberdare and Merthyr works.

At about this time, namely in 1839, the total yield of pig-iron in South Wales was 453,000 tons from about 130 furnaces. These were situated at the following places. The number after the name gives the number of furnaces at the locality, except in those cases where only one furnace was present.

Landore.
Ynyscedwin, 3.
Ystalyfera.
Neath.
Neath Valley, 2.
Maesteg, 6.
Pyle, 2.
Cwm Bychan, 2.
Oakwood, 2.
Gadlys (Aberdare).
Aberdare, 6.
Pentyrch, 2.
Cyfarthfa, 7.
Ynysfach, 2.
Plymouth (Merthyr), 2.
Duffryn, 3.
Penydarren, 6.
Dowlais, 14.
Rhymney, 6.
Tredegar, 5.
Sirhowy, 4.
Ebbw Vale, 3.
Beaufort, 6.
Victoria, 2.
Nantyglo, 8.
Coalbrook Dale, 2.

Blaenau (Blaina), 2.
wm Celyn, 4.
lanelly, Brec., 4.
Blaenavon, 5.
arteg, 5.
Gelynos, 2.
Abersychan, 4.
Pentwyn, Mon., 2.
Pontypool, 3.

Shortly after this time (1851) the mining of iron ore in the rea employed over 10,000 men, while some 15,000 more ere actually engaged in iron manufacture, besides thousands f others who were engaged in other forms of iron-working. t that time no more than 39,000 were employed in the coal ade, which was just beginning seriously to rival the iron ade as the foremost industry in South Wales.

With the growth of the iron industry and the further evelopment of transport facilities, especially of railways and ocks, Cardiff and Newport grew as the chief exporting ntres for the principal iron-making district. The increase the exports of iron from Cardiff, after the construction of he docks in 1839, is shown by the following figures :

1841.	Iron exported . . .	20,000	tons.
1851.	,, ,, . . .	115,000	,,
1861.	,, ,, . . .	187,900	,,
1871.	,, ,, . . .	322,000	,,

The Steel Industry

Until about the middle of the nineteenth century, most the iron made in South Wales was either pig-iron or wrought '-iron, made from pig-iron in a puddling furnace. rom this, steel was occasionally made, but the process was lengthy and the steel so expensive that it did not come to general use. Shortly after 1850, however, Bessemer evised a method of manufacturing steel on a large scale, hich made it possible to produce steel at a much lower price. he Dowlais and other works took up his method, and gradu-ly the making of steel has displaced to a large extent the anufacture of iron. The decline of the old iron industry nd the growth of the steel industry has had interesting ffects in South Wales. The Coal Measure ores, on which he iron industry had been built up, had proved satisfactory

hitherto, but they contained so much impurity, and particularly phosphorus, that they were unsuitable for use in the Bessemer process. In this process the furnaces are lined with silica, in the form of Dinas or silica bricks (generally made from the siliceous materials in the Millstone Grit), and this does not combine with and remove the phosphorus from the steel. Thus there was initiated a new phase in the history of the industries, for the continuation of the acid Bessemer steel process demanded an ore with low percentage of phosphorus. Such ores are found in the hæmatites of South Wales, but these are so inadequate in amount that imported ore was needed to maintain the industry.

A second method of steel manufacture, the open-hearth system, devised by Siemens and Martin in works near Swansea, was introduced at a later date, but this process likewise depended on the use of acid or silica linings, and required ores free from such impurities as phosphorus.

From this stage onwards, therefore, the use of the clay ironstones declined in South Wales, and thus the chief factor which had determined the location of the industry in the north-east portion of the coal-field ceased to operate. Yet for many years the existing facilities kept the industry active in the same area, and the Merthyr Tydfil district became an important centre of steel manufacture (fig. 21). Gradually, during more recent years, this industrial inertia has been overcome, with the growth of new steel works in more suitable areas, and especially near the docks. The nodular clay ironstones continued to be worked in some places in South Wales, and some were smelted locally for the making of pig-iron. As late as 1915 about 15,000 tons were mined at Ebbw Vale and other places, but were mainly sent to Staffordshire, where similar ores are still worked and smelted. With the abandonment of these ores in South Wales, as in most other coal-fields, the coal and the iron ores were no longer worked side by side, and the industry depended increasingly on imported ores. At the present time about two thirds of the iron ore smelted in South Wales is imported (see table, p. 99).

Some iron ores had been imported into South Wales since

he early part of the nineteenth century, but as the century progressed the amount increased rapidly. Some 45,000 tons were imported at Newport in 1820, compared with 240,000 ons in 1847. At Cardiff only 2,000 tons were imported in 841, but this had increased to 44,000 tons in 1851 and to 12,000 tons in 1861 ; after remaining steady near this figure he total imports at Cardiff jumped to over 500,000 tons in 872, although in that year there were also considerable mports at Penarth. Further west, Porthcawl imported onsiderable quantities of ore at about this time, while there vere also large imports at Briton Ferry and Swansea.

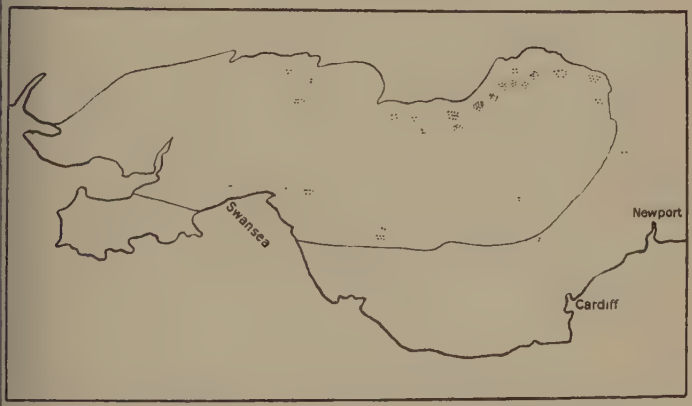


FIG. 21.—Distribution of Furnaces making Pig-iron in 1872
One dot indicates one furnace.

The imported ores were from Spain, Russia, Greece and Algiers, he most important source being Spain, whence large supplies ave continued to be exported to South Wales ironworks.

By 1872 the number of furnaces in South Wales had increased to over 170, not all of which were in blast at any one me ; in that year over a million tons of iron were produced. he distribution of these furnaces is indicated in the map ig. 21), from which it will be noted that the greater number f the iron furnaces were still to be found in the north-eastern art of the coal-field, although steel works were already eveloped in other areas.

Although industrial inertia for some years longer kept the steel industry mainly centred in that portion of the coal-field there was a steady and increasing tendency for it to move towards the ports, and new works have generally been erected in the neighbourhood of the docks. Thus in this last phase of the industry, works have grown up at Cardiff Aberavon, Briton Ferry, Swansea, Gowerton, Loughor and Llanelly, while of the old iron centres on the outcrop of the Lower Coal Series only Dowlais, Ebbw Vale and Blaenavon are now surviving. By this means, the transport of the ore by rail from the docks to the works has been avoided, while the fuel can still be economically obtained and the output is more readily placed on the market.

More recently a further process of steel production has been introduced. This is a ' Basic ' process, and it is applicable either to the Bessemer converter or to the Siemens open-hearth furnace. By the use in the furnaces of special linings of basic material, ores containing phosphorus can be successfully used, the phosphorus being extracted and going towards the formation of a basic slag, which after treatment can be used as a fertilizer. By means of the Basic process it would thus be possible to use the nodular ores which played so important a part in the development of the early iron trade in South Wales, but on account of their thinness and the difficulty of working them (that is, of separating them from the shales among which they are found), they are not now used. On the other hand, thick beds of soft ore in the Jurassic rocks of England (chiefly in Yorkshire, Lincolnshire, Northamptonshire and Oxfordshire), which can very easily be quarried, are made available for steel manufacture by this process (see table II, at the end of this chapter). Their development has contributed largely to the growth of steel manufacture in other regions, notably in Lincolnshire, but some of the ores are now brought into South Wales for smelting, as for example from near Banbury in Oxfordshire.

The number of works which now produce pig-iron in South Wales is small, and although there are some twenty-eight furnaces, only a small proportion of these are in blast. The output of pig-iron has declined considerably in many parts

f Britain during recent years, as will be apparent from the ollowing table.

PRODUCTION OF PIG-IRON IN BRITAIN
(In thousands of tons)

	1913.	1920.	1925.
outh Wales and Monmouthshire . .	889	692	417
erbyshire, Notts. and Northamptonshire	1,166	914	1,011
ancashire and Yorkshire (including Sheffield)	504	592	529
orth-East Coast	3,869	2,639	1,905
incolnshire	450	589	549
affordshire, Shropshire, Warwickshire and Worcestershire	851	697	417
est Coast	1,163	1,009	633

Most of the existing works manufacture steel. There are vo principal processes employed in South Wales at present, amely, the Bessemer process and the open-hearth or Siemens-

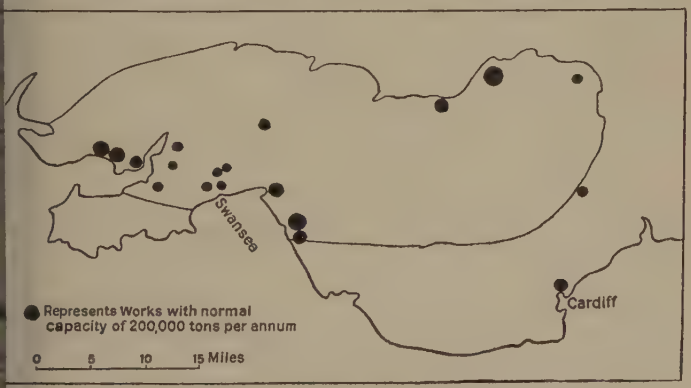


FIG. 22.—Distribution of Steel Works in 1929

ch dot is approximately proportional in size to the normal capacity of the works. Compare Fig. 21.

rtin process, both of which can be worked on either the sic or acid linings. A modern steel works generally consists blast furnaces, steel melting furnaces and rolling mills, e latter producing plates of all sizes suitable for boiler- king and shipbuilding, rails, tubes and rods. In the

Cardiff district and in the areas near the north-east of the coal-field many of the steel works use the Bessemer process, while in the works situated near the coast in the Swansea district, the open-hearth process is mainly employed. This specialization in the western district is in part related to the needs of the tin-plate industry, as will be shown in a later chapter. The number of existing works is smaller than the number of fifty years ago, but each works is so much larger that a greatly increased output is possible. The distribution of steel works is shown in fig. 22, which indicates clearly the growth of the industry in the west and near the coast, as contrasted with the distribution of the iron industry of fifty years ago (fig. 21).

The proportions of the steel produced by the various processes in 1926 are indicated below.

	Open Hearth.		All other Processes.
	Acid.	Basic.	
South Wales and Monmouthshire .	419,000	356,000	127,000 tons
Great Britain	1,055,000	2,265,000	276,000 ,,

SOME STATISTICS OF THE IRON AND STEEL INDUSTRY

I. Production of Steel Ingots and Castings, 1913–25
(In thousands of tons)

	1913.	1920.	1923.	1924.	1925.
Derbyshire, Notts., Northamptonshire, with parts of Yorkshire and Lancashire	417	682	550	506	44
Scotland	1,431	2,074	1,253	1,241	1,07
North-East Coast	2,031	1,951	1,679	1,717	1,46
Lincolnshire	241	330	540	466	41
Staffordshire, Shropshire, Warwickshire and Worcestershire	465	806	892	835	82
West Coast	398	270	193	149	18
Sheffield	879	1,070	1,164	1,031	1,01
South Wales and Monmouthshire	1,807	1,884	2,212	2,256	1,96

[1] The figures given relate to 1925 and earlier years. Industri troubles and trade depression have caused great fluctuations in this an other trades in 1926 and later years. The figures are intended illustrate the relative importance of the industries in post-war yea but the actual output in the near future may be very much larger smaller than that given above.

II. Production of Iron Ore in Britain

(In thousands of tons)

Type of Ore.	Chief Areas.	Amount raised in 1913.	Amount raised in 1925.
Hæmatite	Cumberland	1,767	810
,, . . .	Lancashire	—	142
Jurassic Ores . . .	Lincolnshire, Yorks., Oxfordshire and Northants.	12,572	8,748
Coal Measure Ores .	Mainly North and South Staffordshire	1,542	343
Other Ores		116	34

III. Imports of Iron Ore, and of Iron and Steel, at South Wales Ports, in 1925

(In thousands of tons)

	At Cardiff.	At Swansea.	At Newport.	At Port Talbot.	Total of all Chief Ports.
Iron Ore .	501	56	110	158	818
Iron and Steel .	91	109	556	34	790

CHAPTER X

THE TIN-PLATE INDUSTRY

THE British manufacture of 'tin-plate' is carried on at the present time almost exclusively in the neighbourhood of Swansea and Llanelly.

The reasons for this very definite localization are not obvious, for the region is not one of those which previously had been a centre of the iron industry, nor has it any obvious advantages, other than the presence of coal and the nearness of the well-equipped docks of Swansea.

The practice of giving a sheet of iron a coating of tin was first carried on in Bohemia. A particularly soft variety of iron was produced and beaten into sheets by means of hammers driven by water-wheels. Each sheet was then cleaned and plunged into a bath of molten tin. The two metals in contact formed a film of alloy, to which a layer of tin adhered. Water was required in abundance for the cleaning of the plates, and a good fall was needed to drive the water-wheel, conditions best found in the upper portions of river valleys.

In this primitive form the industry was first introduced into Monmouthshire in the latter part of the seventeenth century.

At this time the iron industry was not very flourishing, partly because of the increasing scarcity of timber and partly because of the increasing importation of iron from Sweden; but it was not until 1720, fifty years after the first experiments at Pontypool, that the manufacture of tin-plates was definitely started.

In a short time the hammers for making the plates were displaced by rollers, which produced a sheet of more even

thickness, and coal was more frequently used for smelting the iron ore. By the end of the eighteenth century three other works had been constructed in Monmouthshire, two in Glamorgan, two in Carmarthenshire and three in Gloucestershire. These were ironworks, and the making of tin-plates was regarded as a profitable sideline.

From that time onwards works multiplied with some rapidity, but until 1850 Monmouthshire remained the main centre, with Glamorgan and Staffordshire close behind in importance. Then Glamorgan became the more important county, and in 1875, when there were 77 tin-plate works in the whole of Britain, 27 were in Glamorgan, 16 in Monmouthshire and 14 in Carmarthenshire.

About 1875 a very important change was made in the method of manufacture. Previously the raw material of the industry had been iron, produced usually in charcoal forges and puddling furnaces attached to the tin-plate works, but just before that date the Bessemer method of steel manufacture was introduced, and Dr. (afterwards Sir) William Siemens in a Swansea works produced a kind of steel which proved to be suitable for rolling into tin-plates. This material has gradually replaced the charcoal iron, which is now no longer used. As a result, steel works grew up in the neighbourhood of Swansea (fig. 22) to produce 'Siemens steel'; these steelworks served very largely as feeders to the local tin-plate works. From that time onwards the tin-plate manufacturers required tin-bars (that is, flat bars of steel of the requisite quality and size) which were specially produced in the local steel works, a condition which appears still further to have tended to the concentration of the tin-plate industry in the Swansea and Llanelly districts (fig. 23). Thus in 1891, a 'peak' year, there were 51 works (277 mills) in Glamorgan, 30 works (119 mills) in Carmarthenshire, and only 11 works (86 mills) in Monmouthshire.

The year 1890 was another critical one in the Welsh tin-plate industry, for this was the date at which its largest customer, the United States, decided to produce its own tin-plate. It was at that time importing more than half of the annual output, and the imposition of a prohibitive tariff was

a tremendous blow to the Welsh industry. But although the tin-plate industry passed through a difficult period, during which works were closed and many workers were unemployed, large numbers emigrating to the new works in America, yet the industry was virile enough to survive and eventually resumed its normal growth. By the year 1913 the output had increased by 50 per cent over that of 1890. Since then the industry has been adversely affected by the Great War and the disturbance in trade which followed it : nevertheless the tonnage produced in 1924 was again equal to the pre-war volume of more than 16 million cwt.

FIG. 23.—Distribution of Tin and Sheet Mills in 1929
One dot indicates two mills.

It has been emphasized already that iron was at first the chief raw material of the industry and that it was later superseded by soft steel ; thus there have arisen trade combinations, including tin-plate works, steel works, collieries and in some cases iron mines. The main constituent in the production of the steel is usually re-melted scrap steel to which varying quantities of pig-iron are added. At present the tin-plate industry consumes one-eighth of all the steel produced in Great Britain. Owing to foreign competition, some imported steel has been used within recent years.

The tin used in the industry at first came from Cornwall It may have been the fact that the iron-manufacturing area

of South Wales was the nearest to the supply of tin and was within the reach of the sea that favoured the initial development of the industry in the area. But very early, even before the end of the eighteenth century, Dutch tin from the East Indian islands of Banca and Billiton began to be imported, and although for a century Cornish tin held its own, the bulk of the metal used in the Welsh tin-plate industry at present is imported, mostly from the Malay States, by way of London. The annual consumption is about 15,000 tons, and this represents about five-eighths of the metal used for all purposes in the British Isles.

The main use of tin-plate is of course the making of containers for food, tobacco and petroleum. In some cases highly decorative designs are printed or enamelled on the tin-plate. Several canister works carrying out this process are found in the Swansea district. Another important use is the making of household utensils. Where lead is not objectionable, as in roofing materials, a cheaper plate known as 'terne-plate' is used, in which a mixture of lead and tin, instead of pure tin, is applied to the steel plate.

Eighty per cent of the tin and terne-plates produced each year are exported, and most of them are shipped from the port of Swansea. Thus the development of that area which was initiated by copper smelting has been continued by the tin-plate industry. The exported tin-plates are sent to many countries; Holland is an important customer, as are also Australia, the Argentine and Canada. Considerable quantities are also shipped to India, Italy, Portugal, China and Japan. The United States, formerly the most important customer, has now become a competitor, and supplies at least half of the Canadian market.

The manufacture of galvanized sheets, used mainly for roofing, is often carried on at the tin-plate works, and most of the works have 'sheet' mills as well as 'tin' mills. These sheets are heavier than the tin plates and are covered with zinc. The sheet industry is a later development than the allied trade, but its growth is not surprising in an area which has been so largely concerned in the manufacture of steel plates, and which is at the same time the centre of British

zinc production. In 1927 about 770,000 tons of galvanized sheets were exported.

With the exception of an important centre in Flintshire and another near Newport, the largest producers of galvanized sheets are in the Swansea district, notably at Gorseinon, Pontardawe and Morriston; in these works are manufactured 50 per cent of the total British production. About 80 per cent of the output is exported, and the principal buyers are India, Australia, Argentina, New Zealand, South Africa, China and Japan. The industry is large enough to use about the same amount of steel as does the tin-plate industry, so that between the two is consumed one-quarter of all the steel produced in Great Britain.

EXPORTS OF TIN-PLATES TO VARIOUS COUNTRIES FROM SOUTH WALES

(The figures represent thousands of tons)

	1879.	1891.	1899.	1905.	1913.	1926.	1927.	1928.
United States	155	325	63	63	21	2	1	1
Russia	1	31	29	6	10	—	—	—
France	5	6	14	14	21	19	11	15
Germany	—	3	—	30	34	6	21	21
China	1	—	6	29	50	19	11	26
Japan						15	16	26
Canada	6	20	21	21	9	25	27	23
Australasia	3	10	12	20	28	43	53	50
Holland	—	5	—	27	43	37	46	49
Belgium	—	2	—	9	13	12	21	19
Norway	—	—	—	7	25	13	18	13
Italy	—	—	—	10	20	13	14	32
Argentine	—	—	—	11	19	12	19	24
India	—	—	—	44	68	11	21	17
Straits						17	25	27
Spain	—	—	—	2	—	16	24	28
Portugal	—	—	—	9	15	13	19	20
Roumania	—	—	—	8	11	3	4	2
Dutch East Indies	—	—	—	—	—	18	19	23
Denmark	—	—	—	3	—	11	12	12
Brazil	—	—	—	8	—	11	22	23
Total Exports	197	448	255	355	494	375	472	532

Estimated home consumption of Tin-plates in 1928, 200,000 tons.

CHAPTER XI

THE COAL TRADE

AS has already been indicated, the South Wales Coal-field consists of an elongated basin which stretches from St. Bride's Bay on the west to Pontypool on the east, keeping roughly parallel for the whole of that distance to the shores of the Bristol Channel. The basin or syncline is narrowest and shallowest in Pembrokeshire, where it is only two or three miles across in some parts. Along the southern border the beds dip steeply to the north, but on the northern border the dip to the south is in most places much more gentle. Within this basin the Coal Measures are at the surface over the whole area, except in a small district north and east of Bridgend, where they are locally covered by Triassic deposits. Thus the South Wales Coal-field is essentially an exposed coal-field, so that its structure can be determined by an examination of the surface rocks, while each coal seam outcrops at the surface. This accessibility of the coal has been an important factor in the development of the coal-field. On the other hand, its structure is more complicated than that of many British coal-fields and the seams are frequently much less regular.

The Coals of South Wales

The development of the coal industry in South Wales has been largely influenced by the high quality and the variety of the coals. In other coal-fields in Britain the seams are predominantly bituminous in character, suitable for house coal, gas-making and a variety of other uses. In South Wales, bituminous coals are present in some quantity, but there are also steam coals and anthracites. Broadly, these

latter fuels differ from bituminous coal in having a higher percentage of carbon and a lower percentage of volatile matter; in other words, the ratio of carbon to hydrogen in anthracite may be as much as 28 to 1, and in a bituminous coal the ratio is more nearly 14 to 1, while a steam coal occupies a position more or less intermediate between these two. These characters are shown in the following table, which gives the analyses of a typical bituminous coal, steam coal and anthracite, calculated on the assumption that the coal is free from ash.

	Bituminous Coal (Mynyddislwyn Vein).	Steam Coal (Four-Foot Seam of Merthyr).	Anthracite (Stanllyd Vein).
Carbon . .	87·66 per cent.	92·0 per cent.	94·43 per cent.
Hydrogen .	6·09 ,,	4·34 ,,	3·33 ,,
Oxygen . .	4·38 ,,	2·44 ,,	1·27 ,,
Nitrogen .	1·87 ,,	1·22 ,,	·97 ,,

Actually, ash is present in every coal; in many South Wales coals it is very small in amount, and this is particularly the case in anthracite. The bituminous coal of which the analysis is given above has an ash content of 5·2 per cent, the steam coal of 3·89 per cent and the anthracite of only 1·1 per cent.

Anthracites are found in the detached portion of the coal-field in Pembrokeshire, and in the north-western portion of the main part of the coal-field, from the Gwendraeth Valley approximately as far as the head of the Vale of Neath. These anthracite seams are in the Lower Coal Series. As they are traced from this area eastwards and southwards towards Pontypool and towards Swansea and Bridgend, they change in character, each seam passing first into a steam coal, then into a bituminous coal. Thus, along the south crop of the coal-field from Swansea to near Newport, the seams in the lower part of the Coal Measures are all bituminous, while in the areas between this district and the anthracite district as at Aberdare and in the Rhondda Valley, they are steam coals of various grades. The higher coals, that is those in the Upper Coal Series, are nowhere anthracitic, and although they tend to have a higher percentage of carbon as they are

raced towards the north-west, they may be regarded gener-
lly as bituminous coals. It is therefore impossible to repre-
ent the distribution of these types of coal in a simple way
n a map, since the upper seams at any locality are different
rom the lower seams. Thus at certain places, for instance,
he uppermost seams (that is, the highest in the series, or
he youngest) are bituminous, and the lowest ones (or oldest)
re steam coal. It is generally found that in any locality
he highest seams, even if they are anthracites or steam
oals, have a somewhat lower carbon-to-hydrogen ratio than
he deeper seams at that place.

It is estimated that of the workable coals in South Wales,
early 50 per cent are steam coals of various grades, while
bout 30 per cent are bituminous and the remainder anthra-
ite. The excellent quality of the steam coals and anthracite
as led to the rapid development of the coal-field during the
ast hundred years, for it may be assumed that the progress
f the coal trade would have been much less rapid at many
tages had the coals been no different in character from those
f other coal-fields. It has proved profitable to face serious
ining difficulties, such as the working of thin seams, in order
o obtain the coals. It is from the collieries supplying first-
lass steam coal that the Admiralty and mercantile marine
ave satisfied their requirements, and it is by its steam coal
articularly that South Wales has made its reputation as
he leading coal-exporting area in the world.

The Beginnings of the Coal Trade

It is uncertain at what date coal was first used as a fuel in
outh Wales, but the existence of pits and coal workings at
arious times in the thirteenth century is known from several
ources. Throughout the thirteenth, fourteenth and fifteenth
enturies coal was worked to some extent in various parts of
he coal-field, at Kilvey near Swansea, by the monks at
Margam, at Caerphilly and Senghenydd, at Llanelly and in
Pembrokeshire. Towards the end of the sixteenth century,
oal was being used in the smelting of copper at Neath, and
t about that time, as we have seen, it began to figure in the
rade of South Wales.

The early methods of working varied with the relief of th ground and the structure of the seam. At one time, larg quantities of coal were collected from the bed of the Usk while on the north of the coal-field most of the early coa getting was done by ' patching ', or digging the nearly hor zontal seams in open workings. In many places the earl workings were bell-pits, a shallow pit being dug near the ou crop of the seam and workings being made outwards from in all directions, until it was considered to be unsafe to pro ceed, when a similar pit would be dug further along the ou crop. When a seam outcropped on a steep hillside, slant and levels were carried in for a short distance.

The chief difficulties of the early miners arose from th danger of the collapse of their workings, from mine gase and from floods. The last-named caused greatest troubl and for several centuries mining could not be carried below th level of the natural drainage, that is below the level at whic underground waters would flow away, either of their ow accord or by way of a narrow adit cut through to a neigh bouring valley.

In a colliery in Elizabeth's reign, each man worked in separate hole by candle-light, with boys working in relay to carry the coal in baskets along the narrow galleries. Prob ably there was no great change in mining practice for century or more. In the seventeenth century coal-minin was so unpopular an occupation that condemned criminal were pardoned by the king on condition that they woul apprentice themselves to Sir Humphrey Mackworth an work for five years in his mines at Neath. Subsequently a offer of captured pirates was also made to the mineowners but this offer was declined.

In the main, these coal-pits supplied the needs of the locality where they were situated, and coal was being used in Eliza bethan times as a fuel in the larger towns of South Wales During the sixteenth and seventeenth centuries, as we hav already noted, increasing quantities were sent by sea t Ireland, France, and parts of England. At that time, as result of the poor land communications, the coal which wa exported was chiefly mined in those places where the sea cut

nto the coal-field, namely, along the rivers flowing into Milford Haven in Pembrokeshire, and near the shores of Carmarthen Bay and Swansea Bay (fig. 2). From these places coal was egularly exported to various ports along the Bristol Channel, ncluding Cardiff, which although only about six miles away rom the coal-field, continued until late in the eighteenth entury to receive regular imports, notably from Tenby and ther western ports. Indeed, in 1775 an official customs eport stated that no coal was exported from Cardiff, 'nor ver can be, its distance from the water rendering it too xpensive for any such sale'—a statement which amply lustrates the dangers of prophecy.

The working of coal near Swansea and Neath made progress s a result of the growth of the copper industry, but there were onsiderable exports from that area and from Pembroke-hire. The coal industry had become so important by 1695 hat a tax of five shillings per ton was imposed on all coals arried by water. At that time London and the more popu-us parts of the south-east of England received their coal hiefly from Newcastle, but from time to time small quantities ere sent from South Wales. Later, between 1745 and 1765, moderate amount of coal was exported to London, varying om 1,800 to 4,000 tons per annum; of this about 75 per nt was exported from Milford, while Haverfordwest and enby contributed the greater part of the remainder. Thus the trade with London the Pembrokeshire portion of the al-field was of greatest importance, the exports from the ain part of the coal-field, sent by way of Carmarthen, vansea and Neath, being quite insignificant in amount. ith Bristol and other Somerset ports, Llanelly, Neath and vansea at this time had a considerable trade; it must be membered that Bristol then was a city second only in import-ce to London, and its influence on the subsequent develop-ent of industries in South Wales was considerable.

The Early Part of the Industrial Revolution

A more important phase in the growth of the coal trade gan during the latter part of the eighteenth century, when th the expansion of the iron industry, coal began to be

generally used in smelting. During the ensuing period th ironmasters acquired and developed collieries, and in man ways improved the methods of mining. Deeper and large pits were sunk, and with the improvements in the steam engine and its use in pumping, it was possible to overcom many of the difficulties of mine drainage. In 1804 a steam engine was installed for pumping at Landore and graduall their use was extended, but not for many years after this wa the use of steam pumps at all common in the coal-field.

During this period the improvement in communications which has already been referred to, led to some developmen in the coal trade, and in some cases the ironmasters dealt i coal as well as iron. The improved transport facilities wer naturally of greatest importance in the eastern part of th coal-field, in the neighbourhood of the ironworks, and by th early part of the nineteenth century this was linked up b roads, canals and tram-roads with the ports of Cardiff an Newport. Newport in particular benefited by the openin of the Monmouthshire Canal in 1789 (fig. 19). Coal carrie on this canal and the associated tram-roads was speciall exempted from the duty charged elsewhere on water-born coal, and the exports from Newport during the year succeeding the opening of the canal, given below, show hov rapidly the coal trade expanded at that date.

Shipments of Coal from Newport (to nearest 1,000 tons) :

1798	10,000 tons	1804	64,000 ton
1799	18,000 ,,	1805	74,000 ,,
1800	32,000 ,,	1806	89,000 ,,
1801	30,000 ,,	1807	109,000 ,,
1802	33,000 ,,	1808	132,000 ,,
1803	36,000 ,,	1809	148,000 ,,

After 1809 the shipments continued to increase steadily, an for many years over 100,000 tons were sent annually fron Newport to Bridgwater, for distribution by canal to part of south-west England, besides a still greater quantity t Bristol.

Not for some years did Cardiff develop an export trad in coal in any way comparable with that of Newport, but th latter port, perhaps largely as a result of the advantage

gained by exemption from the duty already mentioned, became the chief coal port of South Wales, as is shown by the following figures. Swansea remained an important exporting centre, while the Pembrokeshire output, although increased, was very much less than that of the ports in the main part of the coal-field.

Exports of Coal from South Wales Ports, 1828:

	Total Coal and Culm.
Newport	423,000 tons
Swansea	339,000 ,,
Llanelly	92,000 ,,
Cardiff	32,000 ,,
Milford	18,000 ,,

At that time numerous tram-roads, as well as canals, brought coal from neighbouring collieries to the port of Swansea; one tram-road connected collieries near Llansamlet, another, the forerunner of the Mumbles railway, ran along the coast to the Clyne Valley and to Oystermouth. The Port Tennant Canal linked the quay at Swansea with the Neath Canal at Aberdulais. Later, a tram-way was constructed from the Llynfi Valley to Porthcawl, by which coal and iron were conveyed to the coast for export.

During the early years of the nineteenth century, therefore, there was a distinct expansion in the coal trade. More mining was necessary in order to supply coke for the rapidly growing iron industry, but apart from that, an ever-increasing amount of coal was rendered available for local use and for export. These early developments in the export trade influenced first the areas around Carmarthen Bay and Swansea Bay, where the coal is readily accessible and where comparatively little land transport was needed, and secondly, the area occupied by the outcrop of the Lower Coal Series, in the north-east and east of the coal-field. In the latter area, the gentle dip of the rocks made mining moderately easy, and the seams worked were found in close proximity to the ironstones (fig. 4). In the west, the chief developments were on the southern margin and in the synclinal areas occupied by measures above the Pennant Sandstone; the anthracite area was not much developed. It may thus be

noticed that the greater part of the coal-field at this time was quite undeveloped, and westwards from the Taff as far as the Vale of Neath there had been comparatively little growth in the coal industry. Much of Blaenau Morganwg thus remained barren upland, with quite a sparse agricultural population.

The Rise of the Coal Trade

The changes which were taking place in South Wales within the early years of the nineteenth century, however, paved the way for the phase of rapid expansion in the coal industry which may be considered to have begun shortly after 1830 and to have extended into the twentieth century. Many causes contributed to the sudden enlargement of the industry. Among these were the improved mining methods, the greater transport facilities (at first especially inland transport), and later, the removal of the duties on exported coal. But the factors of greatest immediate importance were the opening of mines on the steam coals, especially the celebrated Four-Foot Seam of the neighbourhood of Merthyr Tydfil, and the effects of the London Smoke Acts, which led to a search for a smokeless fuel. Several London coal merchants visited Wales at that time, travelling by land to Bristol and crossing to Cardiff, then a tiny port to be compared perhaps with Cardigan of the present day. Some of them visited a small colliery on the Four-Foot Seam, owned by a widow, Mrs. Lucy Thomas, at Waun Wyllt, near Merthyr, and from that level they arranged for the delivery in London of its entire output of steam coal. The first cargo was shipped in 1850 in a small sloop, the price paid at the pit being about four shillings per ton and the coal selling for about fourteen shillings per ton in London.

This first development of the steam coal trade was soon followed by others. In 1837 the same seam was opened in the Aberdare valley by Thomas Wayne, and coal from it was taken to London. From that time onwards the coal trade of Cardiff grew apace, for that port was clearly the one through which the coals from these valleys were most conveniently exported. The construction of the Taff Vale

Railway, which was completed in 1841 to Merthyr and Aberdare, further helped on the growth of the export trade (fig. 26). In 1841, 41,000 tons of coal and coke were carried by this railway, but the total had increased by 1860 to over 2 million tons. The opening of the Bute Docks at Cardiff in 1839 was another important factor. The exports from Cardiff increased rapidly, overtaking those of Swansea and nearly equalling those of Newport before 1850.

SHIPMENTS OF COAL FROM SOUTH WALES PORTS
(In tons)

	Swansea.	Cardiff.	Newport.	Llanelly.	Milford.
For the period 1816–18 .	638,000	864	?	163,000	1,895
For the period 1819–30 .	2,508,000	650,000	3,033,000	729,000	201,000
For the period 1831–40 .	3,231,000	1,014,000	3,166,000	1,007,000	390,000
For the period 1841–50 .	4,458,000	4,547,000	5,670,000	2,149,000	612,000

For some years the chief exports from Cardiff were derived from the Taff and Cynon valleys. Shortly after 1840 small collieries were opened in the Rhondda valley; one of these, at Dinas, was connected by a tram-way with the canal at Pontypridd. Apart from this, the valley remained practically undeveloped for many years. It was described in 1847 as a glorious green valley, with scattered population living in rude farm-houses; the chief farmer had over 3,000 sheep. Until that time many of the inhabitants had so little knowledge of the existence of coal in the Rhondda that supplies were obtained from Merthyr and Aberdare. It was not until some years later that developments in the Rhondda led to real growth of coal mining in that area, and it was only after 1860 that its excellent steam coal and easily mined seams caused it to rank as one of the important coal valleys. When this stage was reached, Cardiff was established as the leading coal port of the Bristol Channel.

At about that time the bulk of the foreign trade was with

France ; of 1,259 vessels from foreign countries which entered Cardiff docks in 1853, 611 were from France. During the same year over 8,000 vessels arrived from British ports.

The building of railways during this period encouraged further development. Following the construction of the South Wales Railway with its connections to London, it was of course possible to send coal direct by rail to London. The same years witnessed the opening of additional docks at Newport, Cardiff, Swansea and Llanelly. In 1860 over 10 million tons of coal were raised in South Wales, and in 1872 over 15 million tons. In the latter year over 6 million tons of coal were shipped from South Wales, and the foreign trade had then grown to such an extent that more than 3½ million tons were sent to foreign ports. It is interesting to note the amounts of coal sent from the various ports in comparison with the amounts shipped prior to 1851.

Coal Shipments in 1872 :

Cardiff . . .	3,522,000 tons	Llanelly . . .	279,000 tons
Newport . . .	1,012,000 ,,	Porthcawl . .	148,700 ,,
Swansea . . .	758,000 ,,	Milford . . .	46,000 ,,

Thus in little more than twenty years Cardiff's total annual export had increased six times, while that of Newport had scarcely doubled, and that of Swansea had increased by only about a half. The opening of the valleys in mid-Glamorgan had led to considerable exports from Porthcawl, but this trade has since been diverted to Port Talbot and to ports further east. The Pembrokeshire part of the coal-field showed no increase in its production at that time.

By this time parts of the coal-field region had become densely populated, especially in the east and in some areas near Swansea and the other western ports. The greatest number of collieries were to be found in the eastern end of the coal-field, in the Rhondda and the valleys further east (fig. 24), frequently near the ironworks. These valleys had changed completely during these latter years, and had a rapidly increasing population as men poured into the district from over a wide area, attracted by the relatively high wages paid by these industries. In the western parts of the coal-field

however, there were still large areas which were comparatively undeveloped ; mining in the west was mainly confined to the coals of the Lower Coal Series on the north crop, and to the coals in the Upper Coal Series in the synclinal basins (for instance, near Llanelly).

Further demands for the steam coals of South Wales came after 1860 from another source. From about the middle of the century some sailing ships had been fitted with auxiliary steam engines, and the number of steam-ships gradually increased. In 1872 about one-quarter of the vessels entering

FIG. 24.—Distribution of Collieries in 1872

One dot indicates each colliery.
(After T. Forster Brown.)

South Wales ports were steam-ships. The extension in the use of steam power for ships travelling, for instance, by way of the Suez Canal (opened in 1869) led to the establishment of coaling stations, and the Welsh steam coals became the chief fuel for ships on all the world's trading routes. An advantage of the Welsh coals is that they keep well in any climate, while they suffer less than many coals by breakage during handling and transport. The foreign trade was also helped indirectly by the increasing amounts of iron and other ores which were imported into South Wales, for coal provided a suitable return cargo at lower transport costs than would

otherwise have been possible. In a similar way the coal export trade has been influenced to some extent by the sending of return cargoes to the countries from which the large supplies of timber needed for pit-props have been derived.

The developments in the coal trade which took place after 1830 were mainly independent of the ironmasters, and while these latter were mostly Englishmen, the pioneers of the coal trade were chiefly natives of Wales. Some of the ironmasters continued to produce coal for many years, however, and at one stage the two groups attempted to undersell each other by making reductions in wages, a state of affairs which shortly after 1866 led to industrial troubles and finally to a better organization of the industry.

The growth of coal exports led to the need for still greater facilities at the docks, and Cardiff and Newport docks were augmented, while new docks were made at Penarth in 1865 and 1881, and at Barry in 1889 and in 1898. This group of ports continued to advance until it became the first coal-exporting centre in Britain. The exports of Cardiff, Penarth and Barry in 1912 were over 20 million tons (out of a total of 50 millions of coal raised in the whole coal-field), compared with 16 million tons exported from the Tyne ports.

The growth of coal exports from the Swansea district was much less rapid. This was partly due to the facts that a large proportion of the western coals are anthracites, and that no great region of steam coal was available in the coal-field near Swansea (although after about 1890, quantities of steam coal were sent by the Rhondda and Swansea Bay Railway to Swansea). The anthracites were much valued for certain purposes, as for malting, but there were no large exports of anthracites in any way comparable with the exports of steam coal. Before 1850 France was practically the only foreign country which imported anthracite, and consequently the development of much of the coal-field north and west of Swansea and Llanelly did not begin until much later than the developments in the Cardiff districts. Moreover, the iron industry did not extend far into the anthracite area until shortly before 1850, when the discovery of means of using

anthracite in smelting led to developments in the mining of coal in the area. Since that time, this fuel has found a wider market, but as late as 1883 only 509 tons were exported from Swansea to foreign ports. As anthracite is nowhere so abundant as bituminous coal, and since the anthracite of South Wales has no serious rival except perhaps in Pennsylvania, the demand has been steadily increasing, and anthracite is now largely exported for both industrial and domestic uses. On account of its great scarcity in other areas, the development of this form of fuel may be expected to be influenced by other factors than those which affect the export of other coals.

Much patent fuel is made in South Wales, and this coal-field produces the bulk of the output of the United Kingdom. The manufacture of patent fuel on a large scale began about 1860, and the industry has grown in both the eastern and the western portions of the coal-field. A mixture of about 90 per cent of small coal with 10 per cent of coal-tar pitch is generally used, but other binding materials are employed in some cases. In 1870, Cardiff exported about 4,000 tons and Swansea about 18,000 tons of patent fuel, increased in 1913 to 717,000 tons from Cardiff and 924,800 tons from Swansea, besides 242,000 tons from Port Talbot, and 147,000 tons from Newport. The sites of the works are near the docks, and patent fuel is sent to many continental countries.

The number employed in coal mining in South Wales has of course increased proportionally with the output. In 1851, when the coal trade was entering on its burst of prosperity, 31,489 were employed in coal mining in South Wales. In 1921 the number so engaged was 242,611; of these, about 160,000 were in Glamorgan. In that county 33·6 per cent of the males over 12 years of age are engaged in coal mining, and in such areas as the Rhondda Valleys and Maesteg the proportion of adult males engaged in mining is as high as 66 per cent; when the numbers engaged in transport and other services necessary to the coal industry are borne in mind, it will be realized how completely are these districts dependent on the coal trade, and how seriously any depression in that industry must affect them.

Influence of Geological Structure on the Development of Coal Mining

The structure of the coal-field, both as regards its surface form and its geological formation, has largely influenced the course of developments in the industry. In the early days of mining, the outcrops of the seams were opened up to varying extents in almost every part of the coal-field, but gradually, as workings became larger, the greater number were to be found along the north crop rather than the south, since it was there possible to work the seams in open patch-works or in levels, while on the south crop the steep dip made extensive mining more difficult. Many of the early collieries were thus situated in the same area as the iron works (compare figs. 21 and 24). At the same time, however, there was much mining activity in the upper measures which are preserved in the synclines in the areas north of Swansea and westwards to Llanelly.

As the nineteenth century progressed there was a tendency for mining operations in the eastern end of the coal-field to extend steadily southwards from the north crop, and for seams to be worked at greater depths. The sinking of pits in the floors of the deep valleys in this area made it possible to reach these seams at a smaller depth than would otherwise have been the case, and the mining centres were thus drawn into the valleys.

The eastern end of the coal-field, eastwards of Swansea Bay, as already described in chapter I (see fig. 4), is divided into a north trough (the Gelligaer basin) and a south trough (Caerphilly basin) by an anticlinal fold (the Pontypridd-Maesteg Anticline). As a result of this central upfold, the lower seams in its neighbourhood are brought within workable distance of the surface, a fact which has greatly helped mining development. West of Port Talbot, the coal-field syncline is much deeper, both from the greater thickness of the Coal Measures, and from the absence of any large upfold within the basin, and the lower measures have only been worked along the north and south crops, and have not yet been followed into the deeper parts of the basin, where, as at Gorseinon, they may be over 6,000 feet below the surface. In that central part of the basin, the upper measures, that is

those above the Pennant Sandstone, are worked at relatively small depths.

The South Wales Coal-field is peculiar in having its workable seams in two main groups, separated by a thick group of barren sandstones (the Pennant Sandstone), and in no locality are seams from both the upper and lower groups being worked together in one colliery.

The development of the coal-field has also been influenced very largely by other disturbances in the measures, especially in the west, in Pembrokeshire, Carmarthenshire and west Glamorgan. The seams are highly disturbed and faulted, so that mining is much more difficult than in most other British coal-fields, and it is only the special quality of the coals that has stimulated the rapid opening of the coal-field under these difficulties. The north-south faults which cut across the coal-field at more or less regular intervals frequently make natural boundaries between adjacent colliery workings, since any seam on one side of such a fault may be over 200 yards higher or lower than on the other side, owing to the great amount of movement which has occurred along the fault, and it is rarely practicable to follow the coal across it.

The Coal Trade at Present

Of all the coal raised in South Wales, some is of course used locally. A large quantity goes to supply works of various types, and much is made into coke for metallurgical works. In 1913, however, about 70 per cent of the output was exported; the prosperity of the industry is thus to a large degree dependent on the export trade.

Since the early growth of the coal export trade there have been several changes in the markets supplied by South Wales coals. These resulted during the nineteenth century from the growing demands for coal from other countries as they turned towards industrialism, while later, the development of new coal-fields in those countries led to the necessity of seeking markets elsewhere. The development of the coal-fields of Great Britain preceded similar developments in continental countries, and British trade gained greatly from this early start; probably no industrial area gained more

than South Wales. But after more than fifty years of activity, some of the most easily mined seams in South Wales are becoming exhausted, and deeper and more expensive mining is needed; at the same time other countries, formerly customers of South Wales, have developed their coal resources, learning from the experience of the older industrial regions. Thus many old markets have been lost, and as coal production has increased, competition has become more severe in other markets. Since 1920 these effects have been felt more acutely, for the war hastened the process of coal-field development in many countries, and having lost some of its early advantages, the coal of South Wales has to compete with the coals of other countries to an increasing extent. These same factors, of course, affect other British coal-fields, but as so large a proportion of the coal raised in South Wales has been exported, this coal-field has been influenced to a greater degree. The increase in the use of oil fuel for shipping and other purposes has further affected the steam coal trade. These and other influences have been responsible for the difficulties which have become increasingly serious during recent years; by 1923 the shipments from South Wales had risen practically to the figure for 1913, but since that year they have again declined, and the future of the coal trade, and of the towns which depend upon its prosperity, are very uncertain.

During recent years therefore the South Wales coal trade has entered on a period of peculiar difficulty, while the output of certain foreign coal-fields has been increased in varying amounts, as shown in the following table:

Output of Coal and Lignite in some leading Coal Producing Countries, 1913 and 1925

	1913.	1925.
	Metric Tons.	Metric Tons.
Great Britain	292 million	248 million
France (including Alsace)	44 ,,	47 ,,
Germany { coal	141 ,,	133 ,,
Germany { lignite	87 ,,	140 ,,
South Africa	8 ,,	14 ,,
Japan	21 ,,	29 ,,
U.S.A. { anthracite	83 ,,	56 ,,
U.S.A. { bituminous coal and lignite	434 ,,	471 ,,

In 1913 nearly 30 million tons of coal were sent to foreign ports from ports on the Bristol Channel, but the amount was only 21 million tons in 1925. Thus, for example, nearly 6 million tons were sent to South America in 1913, as compared with under 4 million tons in 1925, the decrease resulting largely from competition with the United States, which now sends large quantities of coal to the Argentine and to Chile. The amount sent to the eastern Mediterranean fell during the same period from 3,171,000 tons to 2,233,000 tons. In 1913 the chief markets for South Wales coals were in Europe and especially in the south of Europe. France is still an important customer, but the imports from South Wales are much less than in pre-war years.

Coal is at present exported from Cardiff (including Penarth and Barry), from Newport, Port Talbot, Swansea, Llanelly and Milford. Of the total of 28 million tons of coal shipped from South Wales ports in 1927, the proportions exported by the several ports are shown in the table :

	Tons.	Per cent.
Cardiff (including Penarth and Barry)	17,370,000	61
Newport	4,903,000	17
Port Talbot	2,281,000	8
Swansea	3,198,000	11
Llanelly	248,000	0·88
Milford	201,000	0·72

It is interesting to note that over three-quarters of the coal exports were sent from the eastern group of ports, while Swansea and Port Talbot were the more important western ports. It may also be remarked that of the exports from Llanelly, the greater part (191,000 tons) were sent to foreign countries, while of the shipments from Milford about 95 per cent (that is over 191,000 tons) were taken as bunkers, a fact which explains the relatively high shipments from Milford, for the total amount of coal raised in Pembrokeshire in that year was only 42,000 tons.

The coal shipped from the Cardiff group of ports included nearly 14 million tons sent to foreign countries and 798,000 tons sent coastwise, the remainder (equal in amount to the total shipments of all other Welsh ports except Newport and Swansea) being supplied as bunkers. The proportion of coal

sent coastwise from Newport was higher. The greatest amounts of coal sent coastwise from Cardiff went to Southampton, while the most important coastwise trade from Newport was with Bristol and Avonmouth.

The anthracite industry, as we have noted, may be influenced in its growth by certain factors which do not apply in the case of other coals. The total quantity of anthracite raised in South Wales in 1925 was over 5½ million tons, of which more than half was raised in Glamorgan and most of the remainder in Carmarthenshire. Before the war the quantity raised did not in any year reach 5 million tons, and a greater proportion was then raised in Carmarthenshire, the present tendency being towards the development of the more eastern portion of the anthracite area. More than half of the anthracite which is raised in South Wales is exported, nearly 70 per cent of the exports at present being sent from Swansea, and the greater part of the remainder from Port Talbot and Llanelly. The principal customers (in order of importance) are France, Canada, Italy, Spain, Sweden and the United States.

STATISTICS OF THE SOUTH WALES COAL TRADE

I. Output of Coal from the South Wales Coal-field, 1873–1926

1873	16,180,000 tons	1905	43,203,000 tons
1875	14,173,000 ,,	1910	48,700,000 ,,
1880	21,166,000 ,,	1915	50,452,000 ,,
1885	24,343,000 ,,	1920	46,249,000 ,,
1890	29,415,000 ,,	1925	44,629,000 ,,
1895	33,040,000 ,,	1926	20,285,000 ,,
1900	39,328,000 ,,		

II. Exports of Coal, Patent Fuel, etc., from South Wales Ports 1911–27

	Coal.	Coke.	Patent Fuel.	Foreign Bunkers.	Total Foreign Shipments.
	Tons.	Tons.	Tons.	Tons.	Tons.
1911	25,202,000	111,000	1,595,000	3,802,000	30,727,000
1913	29,785,000	135,000	2,031,000	4,830,000	36,782,000
1919	20,229,000	109,000	1,646,000	3,482,000	25,465,000
1923	30,191,000	327,000	1,062,000	4,230,000	35,739,000
1925	21,454,000	84,000	1,149,000	3,577,000	26,264,000
1927	22,564,000	73,000	1,346,000	4,016,000	28,000,000

III. Exports of Coal from Bristol Channel Ports to certain Foreign Countries

	1913.	1927.
	Tons.	Tons.
France	7,246,000	5,254,000
Belgium	483,000	257,000
Netherlands	115,000	194,000
Germany	295,000	72,000
Spain	1,310,000	1,467,000
Portugal	782,000	703,000
Italy	5,565,000	3,185,000
Gibraltar and Malta	811,000	432,000
Total to all countries	29,876,000	22,592,000

IV. Exports of Anthracite from South Wales Ports, 1927

To France	927,000 tons	To Channel Islands	93,000 tons
,, Canada	598,000 ,,	,, Germany	68,000 ,,
,, Italy	549,000 ,,	,, Egypt	65,000 ,,
,, Spain	124,000 ,,	,, Netherlands	63,000 ,,
,, Sweden	119,000 ,,	,, Irish Free State	43,000 ,,
,, U.S.A.	103,000 ,,		

CHAPTER XII

OTHER INDUSTRIES

SOUTH Wales is an area with relatively few industries; those which have already been treated—the coal and metal industries, together with agriculture—employ a very large proportion of the men in the area, while transport accounts for a further large number. In Glamorgan practically 40 per cent of the adult males are engaged in one or other of these occupations. The remaining industries are therefore relatively of much smaller importance, but some are nevertheless of considerable geographical interest.

It will be noted that there are few occupations for women in South Wales, as compared with those to be found in many industrial areas in the north of England, where for instance the textile trades employ a large percentage of women. In Glamorgan, less than 20 per cent of the adult females are engaged in any occupation, while in Monmouthshire the proportion is only 18 per cent. In Pembrokeshire, on the other hand, it is higher (24 per cent).

In Glamorgan there were only 400 textile workers (apart from makers of textile goods) in 1921, and under 500 workers in leather and skins.

Quarrying—Building Stones

There are several rocks in the area which are suitable for building purposes and which are extensively quarried. Probably the most important of these is the Pennant Sandstone, which in the eastern part of the coal-field, in particular, has been used in the majority of the buildings. The dull grey colour of the houses built of this sandstone contributes to the general monotony of the coal-field valleys.

Elsewhere other rocks have been quarried for building to varying extents. The Trias breccia of Radyr, near Cardiff, has been widely used in that area as a rough ornamental stone. In the Vale of Glamorgan the Lias limestones have been used in building many of the cottages, and in Gower and Pembrokeshire the local rocks, especially the Carboniferous Limestone, have been extensively quarried for this purpose.

Brick-making

The manufacture of bricks is carried on at many places in the coal-field, and at numerous collieries the sha'e and clay brought out from the workings are used for the purpose. Good quality bricks are also made from the red marls of the Trias in east Glamorgan. There are also brick and tile works near Newport.

The manufacture of silica bricks or fire-bricks has already been noticed (page 94). The chief works are to be found on or near the outcrop of the Millstone Grit along the north of the coal-field at various places from Dowlais to Kidwelly. One of the localities has given its name to bricks of this type, and ' Dinas ' bricks are known all over Britain.

In 1921 about 700 men in Glamorgan were engaged in the making of bricks of various kinds.

Lime and Cement

Many South Wales soils are deficient in lime and the manufacture of lime for agricultural use has been carried on for centuries. Lime and limestone have also been exported to other parts of Wales and to neighbouring parts of England from various places along the coast. In parts of the Gower peninsula, where the Carboniferous Limestone is covered by a deposit of Boulder Clay, it has long been customary to add lime to the soil, and small lime-kilns have been used in each village and in some places on almost every farm. Within recent years, however, most of these village lime-works have fallen into disuse, and the manufacture of lime has become concentrated at a few important centres where huge works have grown up and supply all the local needs. Most of these works are situated on the outcrop of the Carboniferous

Limestone, which is generally a sufficiently pure limestone to yield a good quality lime (fig. 2). The most important works are to be found where railways cross the limestone outcrops, as at Machen, Llandebie and Kidwelly.

The Lias limestones are quarried for the making of Portland cement, a cement which has many uses in modern engineering and building, and which has the property of setting under water. This cement differs in composition from ordinary lime, as it contains other substances, chiefly silica and alumina derived from the clays and shales present in the Lias rocks. In making the cement, these shales are used as well as the limestone bands, a certain proportion of purer limestone from the Carboniferous Limestone being added in order to produce a mixture with the required quantity of lime. The cement industry flourishes in the Vale of Glamorgan, on the outcrop of the Lias rocks, notably at Rhoose, Aberthaw, Bridgend and Penarth (fig. 2).

Pottery

The making of pottery has doubtless been practised from very ancient times, and several old potteries are in existence in South Wales, where various kinds of rough ware are made from local clays. The works of Ewenny, near Bridgend, have been active for centuries. An ancient pottery at Llanelly was closed a few years ago, but others still exist near Cardiff and Newport. The clay used at these works is generally of alluvial origin, in some cases being derived from the estuarine muds. The lack of variety in the clay has influenced the lack of variety in the product.

For a very short time in the early years of the nineteenth century, pottery of very high quality was made at Swansea and at Nantgarw in the Taff valley. The excellence of the ware was probably due to the ability of a few workmen and artists. The material used in some cases was an artificial paste or ' frit ', and the location of the works was not dependent on local clays.

Oil

The establishment of the Anglo-Persian Oil Company's refinery near Skewen, a few miles to the east of Swansea, has

led to the growth of the new village of Llandarcy and has made Swansea the chief oil port in the kingdom. At present some 2 million tons of crude oil are imported annually, and nearly the same amount is re-exported after refining. The tankers are discharged at the Queen's Dock into tanks, whence the oil is pumped to Llandarcy.

The Woollen Industry

Some aspects of the early development of the ancient woollen industry were touched on in chapter VI, where its extension to North and Central Wales and its gradual decline in South Wales, towards the end of the sixteenth century, were noted.

Carmarthen became the chief centre of the industry in South Wales and the ' Society of Weavers ' was an important element in the government of the port. Later, the clothiers, tuckers and weavers migrated into the country where they combined their old occupations with farming and grazing. During the eighteenth century there was a gradual adoption of more up-to-date machinery, and an increase in the use of water-power. The development was slow, partly because of the lack of capital and partly because of the conservatism of the people. An attempt was made by the newly formed agricultural societies to foster the industry at the end of the century, and a well-equipped factory was established at Bridgend, but it was abandoned after a short and unsuccessful career.

Flannel weaving did not begin to develop in South Wales until the middle of the nineteenth century, when a number of individual handloom weavers settled in the valleys of the Teifi and the Towy ; these districts have become the chief centres of the industry in South Wales.

In a recent survey it was found that there are in Wales 151 wool factories, and that over 100 of these are situated in the three counties of Carmarthen, Cardigan and Pembroke. Many of them use water as their only power, and are run in most cases by the owner with only one or two helpers. Some are engaged in one or other of the operations of woollen manufacture—spinning, weaving or fulling—some in all three.

There are in addition a number of individual hand-loom weavers to be found in the neighbourhood of the spinning and fulling mills. The following list shows the distribution of the works in certain counties :

	Total Number of Works.	Number using Water-power only.
Carmarthen . .	61	28
Cardigan . . .	32	23
Pembroke . .	14	11
Glamorgan . .	6	3
Brecon . . .	3	2
Monmouth . .	1	1

A similar survey made a year or so previously (1926) showed the existence of 192 factories, and it appears that in the interval 42 factories, or approximately 20 per cent of the whole, had ceased to work.

The larger factories of north Carmarthenshire and those in the adjoining districts of Cardiganshire (at Henllan, Drefach and Pentrecourt) are well equipped and up-to-date, as are also those of Carmarthen and Narberth, some of them employing between 50 and 100 men and women. The position of each factory is largely determined by the supply of water, considerable quantities being required for cleaning and fulling the material. Part of the wool used is English or foreign and of a fine quality. The chief products are blankets and fine flannels, but some firms specialize in shawls, while others make yarn which is knitted on the premises into coats and costumes, and one or two firms make tweeds and suitings. The wool of the Welsh mountain sheep is not suited for these purposes, being short and harsh and apt to be full of ' kemp ' or dead fibre. It is used in the manufacture of ' cartheni ' a very durable kind of bed-rug widely used in South Wales. The heavier flannel is much used for making shirts worn by colliers for work underground.

Fishing

The deep-sea fishing industry is mainly centred on Milford Haven, Swansea and Cardiff. At the 1921 census there were 1,005 fishermen in Pembrokeshire as compared with only 37 in Glamorgan ; of these 255 were registered at Swansea and

103 at Cardiff. As these figures suggest, the greater part of the industry is in Pembrokeshire, but they do not necessarily represent a satisfactory basis of comparison, for many fishermen were at sea at the time of the census. The approximate quantity of fish landed annually is 45,000 tons at Milford, 15,000 tons at Swansea and 10,000 tons at Cardiff.

The fishing grounds visited by trawlers from these ports extend over a very wide area. The chief grounds are in waters to the south and west of Ireland, and in the deep channel which extends south-westwards between north Cornwall and the south of Ireland. Here are several shallow patches, the Labadie Bank (about 90 miles south of Cork), Jones Bank (about 60 miles to the south of Labadie Bank) and the Smalls (west of Skomer Island), which are frequently fished by Swansea trawlers. They also go further south to the neighbourhood of the Scilly Isles, to the coast of Devon and Cornwall and to the shores of Portugal, where they fish in several places between Cape St. Vincent and Cape Finisterre. Along the coast of Morocco the trawlers fish for a distance of over 400 miles, from Cape Spartel to Cape Agula, in water varying from 60 to 350 fathoms. To the north, the Swansea trawlers visit the Klondyke fishing grounds, which lies between the north coast of Ireland and the southern point of the Hebrides. In the past they have worked the more northern Icelandic waters and the White Sea, and it is expected that within a short time they will also visit the Greenland and Newfoundland waters.

By far the most important fish brought in by the trawlers is hake. The approximate proportions of different kinds of fish landed at Milford Haven are as follows :

Hake . . .	40	per cent	of deep-sea	catch
Skate and Ray .	16	,,	,,	,,
Dogfish . . .	6	,,	,,	,,
Megrams . .	6	,,	,,	,,
Bream . . .	4	,,	,,	,,
Ling . . .	4	,,	,,	,,
Conger, nearly .	4	,,	,,	,,
Witches . .	3	,,	,,	,,
Whiting . .	3	,,	,,	,,
Cod . . .	3	,,	,,	,,

Similarly at Swansea, out of nearly 8,000 tons landed by th Consolidated Fisheries Ltd. in 1928, 4,500 tons were hak 580 tons were megrams, 490 tons roker and skate, and 45 tons bream, while the remainder included turbots, plaic soles, ling, conger eels, herrings and mackerel.

Hake is the commonest fish in nearly all the waters visite by the South Wales trawlers. In some areas, as on Labad Bank and the Smalls, however, there is a greater variety fish, while in the Klondyke grounds, herrings and macker are the chief fish. A fair quantity of herrings (reaching total of about 5,000 tons per annum) is brought to Milfor at certain seasons. In general, the types of fish may b contrasted with those landed at the fishing ports on the ea coast of England, where herrings and plaice are among th most important.

Of the fish landed at Milford Haven, 95 per cent is sent b rail out of Wales, chiefly by special trains to London or beyon At Swansea, where a dense industrial population is near the fishing port, a smaller proportion is dispatched to En land, but nevertheless only 20 to 30 per cent is retained i South Wales, the remainder being sent to London (about 3 to 40 per cent) and other parts of England. Some fish sent to France : this is particularly true of the bream, whic is much esteemed in France, but which, although cheap a certain seasons, does not find a ready sale in Wales.

The development of a fishing industry which requires visi to such distant waters has necessitated the use of larg vessels than were formerly used in fishing, and the provisio of facilities for packing and preserving the fish ; thus, ice fa tories have been established at each of the three fishing por mentioned. A dock system well served by railways is als necessary in order that the catch may be rapidly distribute and this has further tended to the concentration of the industr At Milford Haven a canning industry is also developin Fish manure is manufactured at Swansea and Penarth.

Shallow-water fishing is practised at several places along th Bristol Channel. There is also a thriving cockle industry a Penclawdd and at various other places along the coast to th west. The oyster fisheries are not so important as formerl

CHAPTER XIII

INLAND TRANSPORT

IN describing the development of the principal industries of South Wales, reference has been made to the growth of the communications, for in many ways it may be said that the history of industrial development is the history of transport. The growth of trade must always depend on facilities for transport and for the exchange of goods. Although the present chapter, dealing with the development of communications, treats of certain problems which have already been referred to, it is possible in this more complete account of the communications to emphasize other factors to which attention has not yet been given.

Before the Industrial Revolution, as we have seen, transport facilities were few. Most of the trade was by water, and chiefly by sea, since most of the South Wales rivers are only navigable near their mouths, even for small vessels. At that time South Pembrokeshire was at some advantage as compared with other parts of Wales, for the wide inlet of Milford Haven with its various branches made much of that county accessible. As has been indicated in an earlier chapter, land transport before the Industrial Revolution was in a very backward condition. There were few good roads even within the coastal areas, while in the coal-field there were practically no roads at all, except for ancient tracks across the hills which were generally ridgeways. The valleys were usually marshy and impassable. It has been said that until the eighteenth century a journey from South Wales to London was such a hazardous enterprise, owing to the state of the roads, that few undertook it without first settling their affairs. The roads in the lowlands were at that time described as ' public ditches '.

Roads

The first important step towards the improvement of th roads of South Wales was taken by the Agricultural Society o Breconshire in 1755. Landowners in some other counties too similar action in later years, and several better roads wer made. The earliest of these led mainly from east to west, an included the road through the Vale of Glamorgan, and a roa from Hereford and Brecon through Llandilo and the Tow valley to Carmarthen, and westwards to Milford Haven. I was by this latter route that the first mails were conveyed b stage coach in 1787.

Later developments led to the construction of roads con necting these east-west routes, and these developments wer in most cases due to the growth of industrial populations withi the coal-field. The first important road within the coal-field from Merthyr Tydfil to Cardiff, was opened in 1767, havin been constructed as a result of the initiative of the great iron masters. The growth of the iron industry also led to th opening of a road from Merthyr along the Vale of Neath t Swansea, and of a road from Merthyr to Abergavenny. Bu even after that time there was very little further road-buildin in most of the coal-field valleys, which remained without an routes until thirty or more years later.

Meanwhile there were few improvements in the roads of th coastal plateaux. Early in the nineteenth century, as a resul of an inquiry into the state of the roads in South Wales, som of which were said never to have been repaired within th memory of man, a few main roads were made, and the coac services between England and Wales were improved. Befor the coaches gave up competing with railways they were abl on the improved main roads to travel at speeds up to ten mile an hour.

In some parts of the coal-field, and especially in the wes even at the present time there are no roads or only very poo ones along the valleys. Thus in the Loughor valley there i no good road from Ammanford to Pontardulais, and no roa at all along the valley from Pontardulais to Loughor. Th Gwendraeth valley is similarly without any main road.

The early difficulty of constructing bridges over many of the turbulent rivers of South Wales (illustrated by the history of the early bridges at Pontypridd) has influenced road development, and lent an added importance to many bridge towns.

During recent years the increasing use of road vehicles has necessitated great improvements in the roads of South Wales, and to the construction of a number of important new roads, particularly of inter-valley roads. This tendency for road transport to rival and in some instances to replace rail transport, which is so significant a feature of modern conditions, is perhaps less pronounced in South Wales than in many areas, since the goods to be carried are generally heavy and bulky.

The present phase of road usage has led to the increased need for road stones or 'road metals'. In the greater part of South Wales, especially in Monmouthshire, Glamorgan and part of Pembrokeshire, Carboniferous Limestone is chiefly quarried for this purpose; it has the advantage of great abundance in many areas. In north Pembrokeshire various igneous rocks, such as the volcanic rocks of Ordovician age, are quarried for road stone, yielding a very tough and durable material.

Canals

What appears to have been the earliest canal constructed in South Wales was made in about 1769 from Kidwelly to Kymer's Colliery, some three miles distant, being extended some years later. The greater number of canals in South Wales, however, were constructed between 1790 and 1800, as is shown in the table; in England many of the larger canals were constructed at an earlier date.

Dates of Opening of Principal Canals

Kidwelly	1769	Llansamlet (Smith's Canal)	1803
Crumlin (near Swansea)	1789	Swansea	1798
Glamorgan	1791	Penclawdd	1812
Monmouthshire	1792	Llanelly	1812
Neath	1791	Port Tennant	1824
Brecon and Abergavenny (extending the Monmouthshire Canal)	1793		

The more important canals in the eastern part of Sout Wales were constructed to provide means of transport for th iron industry, and served to link up the iron centres wit the ports. Among the promoters of the company formed t construct the Glamorgan Canal were William Crawshay (wh succeeded Anthony Bacon at the Cyfarthfa works) and othe ironmasters. The canal was completed by 1794 and immed ately became the chief means of transport from the ironwork to the docks. Unfortunately there were many disadvantage in the use of the canal ; in about 24 miles it fell from abou 600 feet to sea-level, and so required not less than fifty lock (eighteen of these being within one mile), which necessaril slowed down the speed at which goods could be sent, and le to frequent congestions. Under favourable conditions th journey from Merthyr to Cardiff occupied fifteen hour Further, there appears at times to have been a serious shortag of water in the upper part of the canal, and very soon the cana failed to meet the growing needs of the ironworks. Indeed before the end of the eighteenth century, schemes were on foo for the building of tram-roads to replace the canal. Althoug these schemes did not at first materialize, a tram-road was i 1802 made from Dowlais and Merthyr to the canal wharf a Abercynon (Navigation). In 1818 the canal was extended t Aberdare.

The Monmouthshire Canal, from Newport to Pontnewyd was a more successful undertaking, partly because of th greater privileges enjoyed by its promoters ; it contribute largely to the growth of the iron and coal trades in the earl years of the nineteenth century, making Newport for som years the chief exporting centre in South Wales. The Mon mouthshire Canal was linked up with the Abergavenny an Brecon Canal, and by a number of tram-roads with works a Blaenavon, Ebbw Vale, Sirhowy, etc. (see figs. 19 and 25).

The more important canals in the west were constructed a about the same time. The Swansea Canal, along the Taw Valley, rises through 873 feet in its 17 miles, and consequentl encountered difficulties similar to those which have bee referred to in the case of the Glamorgan Canal. The Neat Canal, made a short time previously, was later connecte

with Swansea by the Port Tennant Canal, which was cut from the Swansea harbour and along the coast, to join the Neath Canal at Aberdulais (fig. 25).

At the time when they were constructed, and in spite of their obvious disadvantages, the canals marked a great advance in the transport facilities and indeed quite revolutionized inland transport in South Wales. Barges capable of carrying more than twenty tons were drawn by horses, and the actual cost of transport was reduced to a fraction of what it had been when roads only were used. Undoubtedly the canals exercised a very important influence on the growth of both

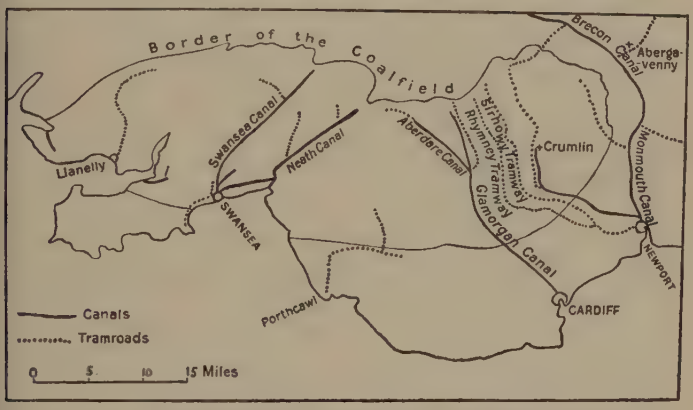


FIG. 25.—The Principal Canals and Tram-roads in 1831

the coal and iron trades, since in each case the goods to be carried were bulky and heavy. But canals can only be made if the conditions are suitable, that is, where there is a supply of water to feed the canal at its highest point, and where the gradient admits of the provision of a convenient system of locks. Thus while the canals were taken as far as possible into the chief industrial areas, the canal companies usually obtained powers for the making, not only of a canal, but also of tram-roads to connect the works and the canal. In many cases it was stipulated that these tram-roads should not be more than a few miles in length, but gradually tram-roads grew in importance and paved the way for the era of railway building.

In 1791 it is said that not one yard of rail-road existed in South Wales, but between the years 1800 and 1830 several hundred miles of tram-roads were constructed. These were built on solid blocks of stone instead of the wooden sleepers which were already being used in other districts, while the rails were flat plates with a side flange, the tram wheels having heavy flat rims.

Some of these tram-roads were quite important undertakings. The Sirhowy tram-road, made partly in accordance with the powers granted to the promoters of the Monmouthshire Canal, can be considered as one of the most important of those made in South Wales. When completed in 1811 it connected Newport with the ironworks at Tredegar and had a length of about 28 miles. The Rhymney tram-way, made some years later, connected the Sirhowy tram-road at Bassaleg with the Rhymney ironworks (fig. 25). These tram-roads, converging on Newport, contributed largely to the early growth of that port.

The tram-roads constructed in the west were in general less extensive. A number linked up the port of Swansea with collieries at Llansamlet and elsewhere, and with limestone quarries at Oystermouth. In that town tram-ways were unpopular with some of the inhabitants, and the construction of tram-roads was opposed on various grounds, including the suggestion that the rumbling of the wagons caused beer to turn sour in the cellars. At Llanelly the Mynydd Mawr tram-road was opened in 1806, and had a great influence on the growth of the town.

Most of the tram-roads had a gauge of 4 feet 4 inches ; that is, about 4 inches narrower than the standard gauge of British railways.

Railways

The era of railway construction commenced in South Wales about 1840, and within two decades the railways had almost completely displaced the earlier modes of inland transport. The earliest railways fall into two groups : first, those which followed the same general directions as the canals and some of the earlier tram-roads, and which served to connect the

industrial areas in the coal-field with the ports, and secondly, the railways which established communications with more distant centres of population. The most important in this latter group is of course the east-west line which now connects Pembrokeshire and the ports of South Wales with London. Indeed, at the present time the dominant characteristic of the railway system is a series of lines in the coal-field valleys converging on a number of towns on the main line from east to west, along or near the coast (fig. 26).

Railways which link the coal-field with the ports have been

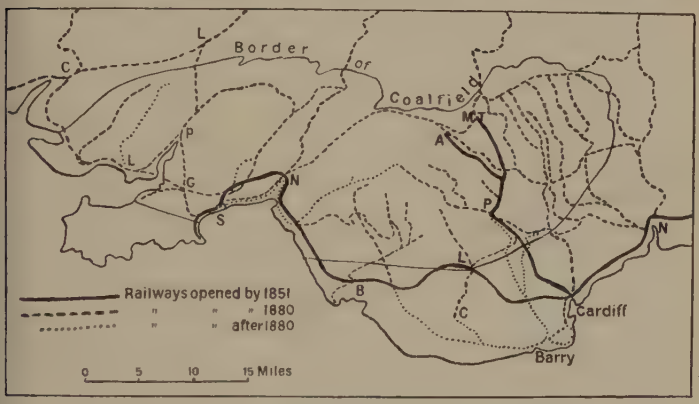


FIG. 26.—The Railways of South Wales

This map illustrates the principal periods of railway construction: note the early railways converging on Newport and Cardiff, and the later railways connecting the coal-field with Barry.

constructed in almost every valley. Some of them replaced earlier tram-roads, and the earliest to be built were along those valleys which had developed before 1830, in which communications of some kind were already in existence. But subsequently, railways were built in other valleys, where they formed, for a time at least, the only means of communication. Thus we find in South Wales certain valleys with railway, canal and road, others with canal and railway but no road (such as the Gwendraeth valley), and others again with a railway but with no canal and no old road, such as the Loughor and Rhondda valleys; these latter valleys are generally areas

which have only been developed to any considerable exten since 1850.

The railways which were constructed in the coal-fiel between 1840 and 1870 generally followed the valleys, and th distinctive relief of the coal-field determined the routes in very definite manner. Thus the railways entering the coa field from Newport and Cardiff passed through the gaps in th escarpments in the Old Red Sandstone and Carboniferou Limestone which there form the coal-field border, while in th west the early railways into the coal-field were along the Neat and Tawe valleys. In the gorges and the narrower parts c these valleys the floor of the valley is almost completely fille by the railways, road and canal.

During the years up to about 1870, railways were built i every important valley in the coal-field. In the east the converged on Newport and Cardiff, in the west on Port Talbot Neath, Swansea and Llanelly, while those in mid-Glamorga radiated mainly from Bridgend (fig. 26).

The earliest railway to be built in South Wales was th Taff Vale Railway, which was built by a company formed b ironmasters and colliery owners who were dissatisfied with th means of transport provided by the canal. The compan received a good deal of support from merchants in Bristol who then depended to a large extent on the products of Soutl Wales industries, and who sought to cheapen transport The bill which was introduced into Parliament in 1836 t permit of the building of a railway from Merthyr Tydfil t Cardiff was strongly—but unsuccessfully—opposed by th canal company, which until that time had of course held monopoly of the coal and iron traffic. The first section of th line was opened from Cardiff to Navigation (Abercynon) i 1840, and to Merthyr Tydfil early in the following year. I was a single line over 24 miles in length, with six passin places, and with short branches to Dinas, in the Rhondd valley, and to Llancaiach, near Gelligaer. It is rather sur prising to find that for many years the railway was not profitable concern, but with the development of other rail ways, leading to the linking up of the Taff Vale Railway wit other parts of Britain, it increased considerably in importance

It was not for several years after the opening of the Taff Vale Railway that the great rush of railway construction began. During 1845 and 1846, five new lines were authorized for South Wales. These included the South Wales Railway, to connect Chepstow and Swansea, a line linking Newport and Hereford, by way of Abergavenny, the Vale of Neath and the Ogmore and Llynfi lines. A connection between the Taff Vale Railway at Quakers Yard with the Hereford line linked up the South Wales industrial areas with the English Midlands in 1858. The Taff Vale Railway, of course, met the South Wales Railway at Cardiff and so made connection with the south of England, although difficulties had to be overcome in the different gauges of the rails on these two lines, the Taff Vale Railway having the standard gauge adopted by the early railways in the north of England, while the South Wales Railway had at that time the wide gauge of seven feet adopted by certain lines in the south.

The South Wales Railway extended across the north of the Vale of Glamorgan, keeping near the coal-field margin and, where the escarpments of the coal-field border are inconspicuous, passing over the Coal Measures. This railway thus touched Llantrisant and Bridgend, which grew as important junctions with valley lines, while Cowbridge, hitherto the chief town on the Vale, remained a small agricultural centre (see table, p. 166). Further west, the railway followed approximately along the course of the old road to Neath, the engineers having been compelled to find a crossing near that town rather than near the mouth of the Neath river in order to avoid interference with the shipping which at that time used the river. As a consequence, the railway was compelled to proceed behind Kilvey Hill and through the Tawe gorge into Swansea, instead of crossing near Briton Ferry and following a route along the foreshore.

The first passenger train on this railway reached Swansea in 1850, after which the line was extended westwards to Carmarthen and later (1853) to Haverfordwest. Owing to the situation of Swansea south of the Tawe gorge the main line was carried westwards from Landore, and it is only recently that all the main-line traffic has passed through Swansea.

The line was planned by the famous engineer Brunel, wh intended to carry it into north Pembrokeshire, and cutting were made for that purpose, but no lines were then laid i that direction ; that route became important, however, i 1906 when the Irish mail service was established from Fish guard to Rosslare. It is significant that proposals to make main road to Fishguard with a view to developing that plac as the Irish mail port, had already been put forward a centur earlier.

Towards the east, the South Wales Railway was at firs built only as far as Chepstow, and it was not until the Chep stow bridge was completed in 1852 that railway communica tion with London was established. An alternative route t Bristol and the south-west of England was provided in 1863 b the steamer from Portskewett ; Bristol had been linked wit London by the Great Western Railway at an early date an had become an important railway centre before the end of th first half of the nineteenth century. The distance to Londo and Bristol was still further shortened in 1888 by the openin of the Severn Tunnel, which brought Cardiff one hour neare London.

Other connections with England were obtained by th construction of railways from Merthyr to Abergavenny an the north, from Swansea through Llandilo and ' the Wells to Shrewsbury and from the same port along the Tawe valle to Brecon and Hereford. These several lines have been o varied importance as affording connections between Sout Wales and the agricultural areas of England and Wales.

All the lines which have been dealt with appear to follo routes which are more or less obviously determined by th relief, avoiding unnecessary gradients and taking advantag of gaps where it is necessary to pass from one valley to another Nevertheless, some of these railways pass over very high ground. With the later developments of railways within the coal-field, however, it has frequently been impossible to avoid tunnels and large viaducts, for these railways in certain cases have been built to link up valleys within the coal-field or to connect areas with ports other than those to which their products had previously been taken. The construction of

these later railways, often after 1880, was necessitated by the expansion of the coal trade and in some cases by the inadequacy of the docking facilities at some ports. Thus, for instance, the Rhondda and Swansea Bay Railway made it possible to convey coal from the Rhondda valleys to the more western ports, rather than to Cardiff, which of course forms the natural outlet for the products of those valleys. The Rhondda and Swansea Bay Railway follows the Avon valley and reaches the Rhondda after a tunnel of about two miles in length (fig. 26).

The Barry Railway was made to bring coal to Barry docks, which had been constructed on account of congestion at the docks at Cardiff and Penarth. Sanction for the Barry Railway was given in 1884, by which date many of the more obvious routes into the coal-field were occupied, and consequently several difficulties were encountered in its construction. Thus the Barry Railway reached the Rhymney valley after tunnelling through the escarpment of the Carboniferous Limestone near Tongwynlais and crossing the Taff and Rhymney valleys by enormous viaducts.

The more important railways of South Wales may be grouped as follows :

(1) The Great Western Railway main line from Pembrokeshire to the Severn Tunnel and to Gloucester, which as far as possible follows the lower ground of the coastal plateaux. Its connections with London, with the south-west and with the north of England are the most important links between South Wales and the rest of Great Britain.

(2) The numerous lines extending along the valleys which penetrate the coal-field, converging on the ports where they join with the Great Western main line, and stretching northward like the bars of a grid. These were mostly constructed during the early phase of railway building.

(3) The railways of the coal-field which give connections between the various valleys, sometimes by tunnels but frequently by taking advantage of the strike valleys

or other gaps. Thus there is a continuous chain o railways along almost the whole of the north crop o the coal-field, chiefly along the strike valleys forme by the outcrop of the Lower Coal Series. Anothe line of inter-valley connections extends along th middle of the coal-field from Pontypool to Maesy cymmer.

(4) Other connections with the north, through Wales Among these may be mentioned the line from Swan sea to Shrewsbury and that from Swansea to Hereford

Thus the coal-field region is well supplied with railways, a essential factor in the development of the coal trade with th heavy transport which it necessitates. South Wales as whole has more railways for a given area than any other par of Britain except the Metropolis, a fact which has partl resulted from the relief of the coal-field, a separate railwa being needed for the opening out of every valley. The traffi carried by these railways is of course mainly coal, as is indi cated by the fact that 114,000 coal wagons were in use on th railways in South Wales in 1913.

The coastal areas to the south of the coal-field are not s well provided with railways. The Vale of Glamorgan i crossed by the Great Western Railway's main line to the west as it was crossed by the early road to the west. The Vale o Glamorgan Railway runs near the south coast and links a series of small villages from Bridgend to Barry. The penin sula of Gower is not well served by railways, its form making it necessary for the main railway lines to pass to the north of the Loughor Estuary, as did the early roads to the west Thus Gower has no railways except the old Mumbles line (now electrified) along the western side of Swansea Bay, and anothe line along the north-west coast from Gowerton to the margin of the coal-field at Penclawdd and Llanmorlais, a district in which there has been some industrial activity.

The building of railways led to the rapid growth of many towns along their routes, especially at junctions or points where two lines crossed. Of several instances which might be mentioned, reference may be made to Gowerton where the

London Midland and Scottish Railway to Shrewsbury crosses the main Great Western line. At this point, first a steel works and later tin-plate works were erected and in a short time it became the centre of a considerable community. The excellent railway communications, including the branch to Penclawdd just referred to, made it a suitable site for a mart serving a very large area. On account of the relief of the coal-field, such nodal points are not so typically developed as in some areas ; the most important railway centres are at the ports or at confluences, where several valley lines converge.

CHAPTER XIV

PORTS AND SHIPPING

Early Conditions

THE industrial development of South Wales has bee largely influenced by its export trades, and especiall by the coal export trade. The construction of doc and the provision of facilities for the shipping of coal ha been vital factors in the development of the area. Before t Industrial Revolution, and for many years after its commenc ment, there were no docks in South Wales, and the shippi of cargoes was done at small quays in the estuaries of t rivers, as at Milford, Carmarthen and Swansea. The vess engaged in trade in those days were always small and th could enter even shallow estuaries without much difficult the vessels lying on the mud when the tide ebbed. As h already been pointed out, the chief ports were not tho which have since become important. The chief ports South Wales in 1701, with the shipping registered at eac are given below ; the figures relate to the principal ports an to the subsidiary ports or creeks which were then group with them for official purposes.

Ports of South Wales in 1701

	Ships.	Total tonnag
Chepstow (with Newport as a subsidiary creek)	28	744
Cardiff (with Penmark, Aberthaw and Newton)	11	218
Swansea (with Neath)	37	1,468
Milford (with Haverfordwest)	32	995
Pembroke (with Tenby)	4	97

The importance of Swansea and Neath at that time clearly shown by these figures, for not only was the tot

number of ships registered at those ports greater than the number registered at the other groups of ports, but the ships were larger on an average than those of other ports: thus the ships registered at Swansea and Neath averaged about 40 tons, while those of Cardiff and its creeks were much smaller, having an average of only about 20 tons.

Before the end of the eighteenth century, Swansea had grown as a centre of the copper industry, and in 1793 over 2,000 vessels visited the port. In 1796 the ships registered at the ports of South Wales were distributed as follows:

	Ships.	Tonnage.
Cardiff	30	1,069
Swansea	85	4,929
Llanelly	63	2,081
Milford	13	694
Pembroke	106	4,144

Thus the average tonnage of the vessels registered at Swansea had increased to nearly 60 tons, while there was a corresponding increase both in the numbers of ships and in their average size at most of the remaining ports.

These changes continued steadily as the trade of South Wales grew; naturally, similar changes were taking place in the shipping of Britain as a whole, partly because of the increased trade and the greater distances ordinarily undertaken. Thus the ores imported into South Wales came from regions further afield, while as the nineteenth century advanced, coal was sent almost over the whole world. Thus by 1840, 492 ships with a total registered tonnage of 41,000 tons were registered at Cardiff, while in 1870 the number registered was 6,892 with an average tonnage of nearly 240 tons. After that time the increase in the proportion of steamships and the building of iron ships led to still further increases in the sizes of the vessels. The average tonnage of vessels using South Wales ports at present is about 800 tons.

The Docks of South Wales

As the ships became larger and the amount of trade increased it became necessary to provide greater facilities than existed in the quays and shallow estuaries. Docks

were thus constructed to meet the growing demands of trade
As we have seen, at Swansea it was chiefly the needs of th
copper smelters which led to the building of the first dock
while at Cardiff it was more especially the coal and iro
exporters who needed docking facilities, for the importatio
of iron ore had not then reached great dimensions. Th
provision of facilities at Swansea led to the growth of coa
exports, and at Cardiff made possible the importing of iro
ore and so helped forwards the next phase in the developmen
of the steel industry. Indeed, it may be suggested that th
construction of docks was a step which opened out possibilitie
of trade expansion in many directions. The extent to whic
these advantages were utilized was controlled by severa
factors, sometimes depending on the personal influence o
industrial pioneers, and sometimes on purely geographica
considerations.

The Bute West Dock was one of the earliest to be opene
in South Wales ; it was opened in 1839, having been con
structed on the initiative of the fourth Marquis of Bute. I
was suitable for its purpose and it is still used by small vessel
including some engaged in coastal trade, but the continue
growth in the vessels using the port led to the making of th
Bute East Dock in 1855, which is used by vessels of ove
8,000 tons. The Roath Basin was added in 1874 to replac
what had been a tidal harbour, and the Roath Dock followe
in 1887, the Queen Alexandra Dock in 1907 ; these give a
area of 165 acres of deep water (fig. 27).

Meanwhile other ports had found the need of docks. New
port opened its first dock in 1842, while others have bee
added at intervals since that time. Swansea did not ope
its earliest dock (the North Dock) until 1852, but the Sout
Dock was added in 1859, the Prince of Wales Dock in 1881
the King's Dock in 1904, and the Queen's Dock, to the sout
of the King's Dock, in 1920 (fig. 28). The area of its firs
dock was only 11½ acres, but the total deep-water area is no
280 acres. Actually the first dock to be opened in Sout
Wales was at Llanelly, in 1836, and it was the increased trad
which resulted that led to the movement for constructin
docks at Swansea. In the development of these dock system

the high tides of the Bristol Channel, rising to heights varying between 20 and 40 feet, have been a factor of some importance.

The growth of coal exports at Cardiff about the middle of the nineteenth century led to the development of the natural harbour formed by the western side of the river Ely, and Penarth Dock, under the shelter of Penarth Head, was opened

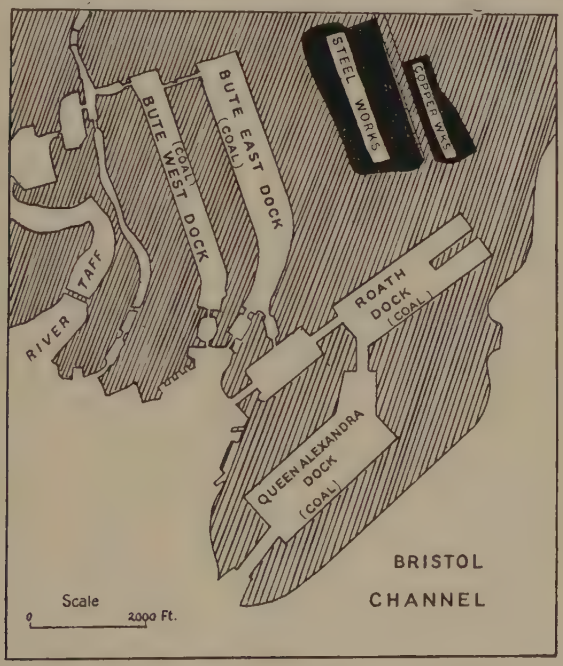


FIG. 27.—Sketch Map of Cardiff Docks

in 1865. The Taff Vale Railway was extended so that coal from the Aberdare and Rhondda valleys could be brought to the dockside, and in 1866, the first complete year after the opening, over half a million tons of coal were shipped at that dock.

Later on, the further increase in coal exporting, partly a result of the rapid increase of mining in the Rhondda valley, led to serious congestion at the docks, and consequently the

exporters sought powers to construct a new dock at Barry with railways to connect it with the chief mining areas

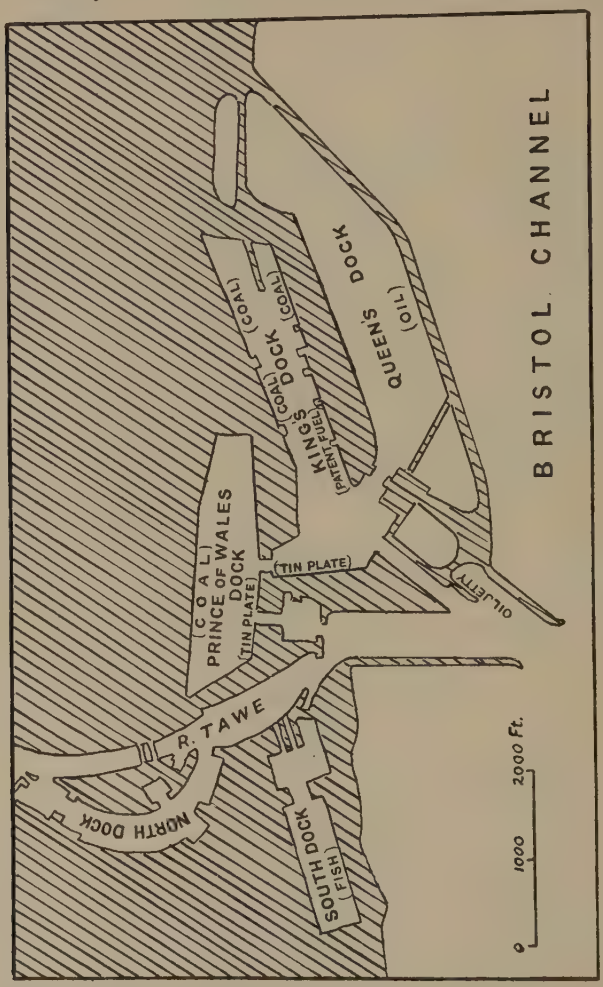


FIG. 28.—Sketch Map of Swansea Docks

Barry Dock was opened in 1889, a further dock being added in 1898. Barry has the advantage of having its dock entrance near to deep water, and vessels of all sizes can enter the dock

over a wide range of tide. The exports of coal from Barry increased rapidly and in 1901 the total was actually greater than that of Cardiff, although the building of additional docks at Cardiff again enabled that port to regain the lead.

In a similar manner the development of the Rhondda Valley and the mid-Glamorgan areas of the coal-field led to the expansion of the Port Talbot dock. A small dock was opened there in 1837, but the modern docks were not provided until 1898, when the railway connection by the Rhondda and Swansea Bay Railway made it convenient to export steam coal from the Rhondda valley at this port. It is also the most convenient port for exporting a large part of the output of coal from the Avon, Llynfi and neighbouring valleys.

The growth of dock facilities has very largely been the development of facilities for the export of coal, and particularly of means of shipping coal. In the early days of the coal trade, very primitive means were employed, but later tips of various kinds were devised. Some fifty years ago the tips at the Cardiff docks were worked on the counterbalance principle, the wagons being drawn by horses on to the tip-cradle, when the weight of the wagon tilted the cradle sufficiently for the coal to be turned out into the shute. A few years later, however, hydraulic power was introduced, and various improvements in the methods of loading coal have been adopted. Appliances capable of tipping 20-ton coal wagons are installed at all the important ports.

During the nineteenth century the introduction of iron ships might have been expected to lead to the development of a shipbuilding industry in South Wales, but although shipbuilding had been carried on, as at Neath, from very early times, this new opportunity was missed. Ship-repairing is of course done at most of the ports, and there are systems of dry-docks at each of the important ports.

It is notable that at present comparatively few passenger vessels sail from South Wales ports, and that the shipping is chiefly related to the transport of goods. Thus, while there are many regular lines of steamers, many of the vessels are tramp steamers engaged on the open carrying trade of the world and not on specific routes.

The Trade of South Wales

The nature of the trade of South Wales is indicated in the table of imports and exports of certain ports given on p. 151, and a study of it serves to emphasize the facts of industrial development discussed in previous chapters, and to indicate the relative volumes of the trade at the various ports. The figures given relate to 1927, a fairly typical year of post-War trade. The figures for 1926 were much smaller, on account of industrial troubles. In certain cases the trade is not equal in amount of that of 1913, and it is uncertain to what extent the effects of competition will lead to permanent and far-reaching changes in South Wales industries.

It will be noted that the bulk of the imports of iron ore are landed at Cardiff, with Port Talbot and Newport taking much smaller quantities. The large imports of iron and steel should also be noted; part of these imports is utilized locally, while part is consigned to Birmingham and other English centres. The imports of non-ferrous ores and of copper, as might be expected, are greatest at Swansea. The imports of timber and pitwood are considerable at most of the ports.

The importation of grain and flour is largest at Cardiff; at Swansea and Barry also increasing quantities are imported. At Cardiff nearly 50,000 tons of fruit are now dealt with yearly. Cardiff is the chief potato importing centre in Britain, and also imports live cattle. It has already been shown that the fish trade is centred chiefly at Milford Haven, Swansea and Cardiff.

The importing of crude oil and the exporting of refined oil is almost confined to Swansea, which has within a few years become the greatest oil port in the kingdom, as a result of the location of the National Oil Refineries at Llandarcy, near Skewen.

It will be noted that in total bulk the imports are not equal to more than a fifth of the exports, although the proportion is higher at Cardiff and Swansea. Naturally, a large proportion of the exports (more than 90 per cent) consists of coal, coke and patent fuel, and of this over 60 per cent passes

through the Cardiff, Penarth and Barry group of ports. Newport is the chief exporting centre for iron and steel, but the total export has decreased considerably of late years; thus Cardiff exported 180,979 tons in 1913, as against only 68,023 tons in 1925. The export of tin-plates is naturally greatest at Swansea, the figure at Newport, which exports most of the produce of the Monmouthshire mills, being much lower.

IMPORTS AND EXPORTS OF THE CHIEF PORTS, 1927

(In thousands of tons)

	Cardiff.	Swansea.	Newport.	Barry.	Port Talbot.	Penarth.	Totals.
Imports.							
Iron ore	516	5	55	—	128	—	704
Copper and other ores	5	94	2	—	8	1	112
Iron and steel	112	232	784	—	29	—	1,157
Timber	172	40	55	8	3	—	279
Pitwood	546	84	108	179	155	—	1,072
Grain and flour	261	101	3	117	—	—	481
Oil	4	1,346	—	1	—	14	1,364
General merchandise	324	136	40	11	5	39	553
Total Imports (including goods not specified above)	2,019	2,086	1,083	387	341	55	5,971
Exports.							
Coal and coke	7,291	3,265	4,982	7,900	2,218	2,226	27,881
Patent fuel	455	640	—	—	63	—	1,157
Iron and steel (rails and iron work, etc.)	80	218	344	3	7	—	651
Tin-plates, etc.	12	450	54	2	1	—	520
Cement	15	5	30	59	—	12	121
Grain and flour	55	16	—	16	—	—	87
Oil	5	996	—	1	—	—	1,002
General merchandise	34	91	6	17	13	2	163
Total Exports	7,948	5,680	5,417	7,997	2,302	2,240	31,584

At Barry there are few imports except pitwood and very few exports except coal; there are no patent fuel works at that port and the export of metal goods is small, but there is a considerable export of cement, a result of the proximity to the lime works of the Vale of Glamorgan. The exports of Barry are twenty times as great as the imports. The trade of Port Talbot also is mainly concerned with coal exports

CHAPTER XV

POPULATION CHANGES IN SOUTH WALES

THE changes in South Wales which have been traced in the preceding chapters have led to changes in the distribution of population. From the time of the Industrial Revolution continuously until the present day there has been a movement of people into South Wales from other areas and especially from the neighbouring areas, a movement which is comparable with those which have occurred in all the industrial regions in Britain. Thus the population of South Wales has increased at a remarkable rate during the last 150 years. The county of Glamorgan in particular has received great numbers of immigrants, its population increasing from 70,879 in 1801 to 1,252,481 in 1921.

During these years there has not only been a great influx of people into the area, but there have also been movements of population within the area, as industries have changed their centres under the influence of varying conditions. It is clear, therefore, that an understanding of all the facts discussed in the previous chapters is necessary before there can be a complete appreciation of the factors which have determined the growth of towns and the movements of population.

As we have noted, the prehistoric inhabitants were chiefly to be found on the exposed moorlands, such as Blaenau Morganwg, and it was not until much later that the coastal plateaux became the more densely populated areas. From that time until the early days of the Industrial Revolution, such areas as the Vale of Glamorgan and Gower were much more populous than the barren hill country of the coal-field.

Thus the chief towns were situated on or near the coast: plateaux, where there was a considerable population devote to varied agricultural pursuits, while the barren uplands wer uninhabited except for shepherds living in scattered dwe lings. The difference in the density of the population i these regions during the Middle Ages is reflected broadl by the distribution of the village churches. In the Vale c Glamorgan, in Gower and in most of Pembrokeshire, church are to be found in the centres of small villages at distances c only a mile or so, but in the uplands the old churches, situate high on the hills (rarely in or near the valleys) are often man miles apart. The same general facts of the early distributio of population are indicated by the sizes of the parishes in thes areas. Thus, in the Vale of Glamorgan the average size c a parish is a little over 1,000 acres, and in Gower is abou 2,000 acres, while the parishes in the coal-field are muc larger. Some of the coal-field parishes have been subdivide within the last century on account of the great increases i the population, but in 1851 the parish of Llantrisant had a area of nearly 17,000 acres, that of Merthyr Tydfil over 15,00 acres, and the majority of the coal-field parishes were at leas 5,000 acres in extent.

Population Changes

The first census of the people of England and Wales wa taken in 1801, and we have no complete information of th distribution of the people before that date. The populatio of Wales was then 587,200, as compared with an estimate population of just under 400,000 in 1690. Already in 18c the first effects of the Industrial Revolution had made them selves felt in Wales, but the areas which had been influence were small, and the distribution of population revealed b the first census affords some indication of the grouping of th people before the coming of industrialism. The density c population in the Cardiff and Swansea areas is shown diagram matically in figures 29 and 31. In these and in the simila maps which accompany them the denser population is show by the darker shading, while the same scale of shading is use on each map so that direct comparison of the maps ma

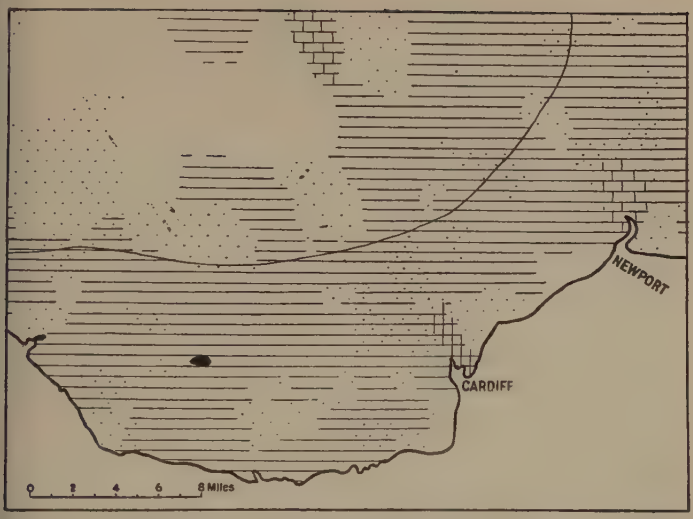


FIG. 29.—Distribution of Population in the Eastern Part of the South Wales Coal-field in 1801

The areas are shaded on the assumption that the population is spread evenly over each parish. The index to the shading is given in Figs. 31 and 32.

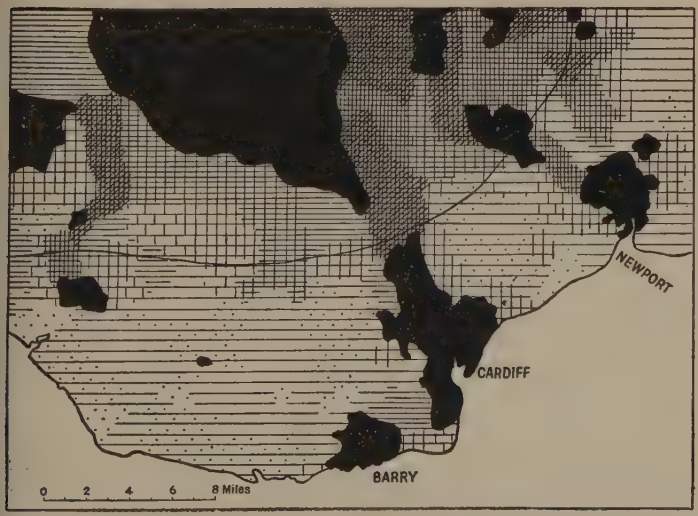


FIG. 30.—Distribution of Population in the Eastern Part of the South Wales Coal-field in 1921

be made. A single parish is the unit of area considered making these maps, and it has been assumed that the population is evenly spread over each parish.

It will be noted that in the Vale of Glamorgan in 1801 the average density of population was between 50 and 100 persons per square mile, falling below 50 per square mile only in few areas (fig. 29). The Gower peninsula shows a similar density (fig. 31). In the coal-field immediately to the north of Cardiff the average density was approximately the same but in wide areas of mid-Glamorgan there were fewer than 25 people per square mile. On the other hand, a small area near Merthyr Tydfil already showed the heavier population of a developing industrial region. The coal-field north and west of Swansea was less sparsely peopled than many parts of Blaenau Morganwg, there being no areas with less than 5 persons to a square mile, and few with less than 50, probably because the coal-field region in the west is not occupied by so extensive a tract of elevated plateau. The early development of industry, particularly of the copper trade and coal exporting, had led to a heavier population at Swansea and Neath.

During the early part of the nineteenth century the population increased at a great rate, and it was not uncommon for the population of any parish in the north-east of the coal-field (that is, in the principal iron-manufacturing area) to be doubled in the ten years between one census and the next. By 1851 the expanding iron trade had almost reached its greatest development, and parishes in the north-east of the coal-field supported populations of more than one thousand per square mile. The growth of the coal trade had led to further increases in the valleys of Monmouthshire and east Glamorgan, so that east of the Taff and Cynon valleys most areas had more than 200 persons per square mile. Between this area and the Neath valley, however, there were few parishes with a density of more than 100 per square mile while some areas were still almost uninhabited. Further west, in the Tawe and Neath valleys, were several areas with over 200 people to a square mile, while in Carmarthenshire there had also been some increases in population, especially

along the shore of the Loughor estuary, as at Llanelly. The total increase in the population of Carmarthenshire, however, was much smaller than that in Monmouthshire and

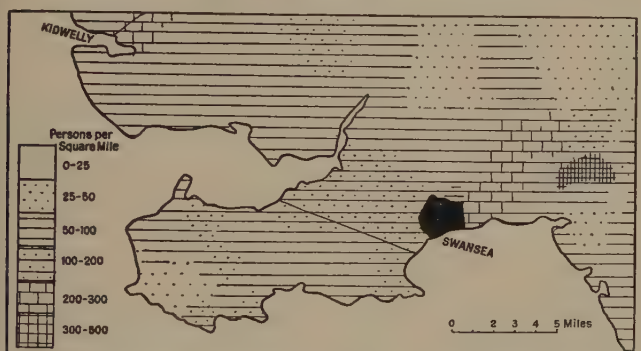


FIG. 31.—Distribution of Population in the Area around Swansea in 1801

The index to the darker shading is given in Fig. 32. The border of the coal-field is indicated by the lines in north Gower and near Kidwelly.

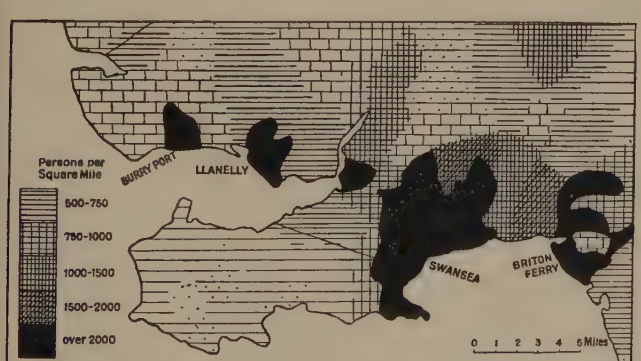


FIG. 32.—Distribution of Population in the Area around Swansea in 1921

The index to the lighter shading is given in Fig. 31. The border of the coal-field is indicated by lines in north Gower and near Kidwelly.

Glamorgan ; indeed, between 1801 and 1901 the population of that county approximately doubled, while during the same period the total population of the whole of Great Britain was

increased by more than three times. Within recent yea coal-field development has been somewhat more rapid in t Carmarthenshire portion of the coal-field.

By the beginning of the present century, very many chang had occurred. Except in Pembrokeshire, the coal-field h become the most densely populated region, and vast are in the eastern part of the coal-field had a population of mu more than 2,000 persons to each square mile. On the oth hand, some parishes to the north and west of Swansea we still relatively undeveloped (fig. 32). The most importa factor in the changes during this later period was of cour the expansion of the coal trade, and the progressive openi up of mining areas in the less accessible parts of Glamorg and Carmarthenshire. Along with this increase in populati in the coal-field there was a similarly rapid increase in t population of the ports, and Cardiff, Newport and Swans grew apace during this period, the population of Cardiff bei roughly proportional at all stages to the total of its coal expor The later years of the nineteenth century also witnessed t dramatic rise of Barry from a tiny hamlet with a populati of about 100 in 1881, to a thriving port with 13,000 inhabita in 1891 and 38,900 in 1921.

Not only were there increases in population in the coa field and at the ports, and a gradual spreading of the urb populations into the parishes surrounding the ports, b striking increases also occurred along the valleys or lin of transport between the ports of the coal-field (see especial fig. 30). Apart from these changes and the growth of re dential and holiday towns such as Porthcawl, the populati of the areas outside the coal-field underwent very little chang Thus the greater parts of the Vale of Glamorgan and of Gow were only a little more densely populated in 1921 than 1801, and still remain essentially agricultural areas, sharp separated from the areas of industrial development. It likely that recent tendencies, especially since the 1921 censu towards the wider diffusion of the urban populations, help by the improvement of roads and the expansion of road tra port, will considerably modify these relations in the futur

The changes in the population of South Wales, whi

occurred during the nineteenth century, represent of course only one aspect of the widespread changes in the density and the distribution of the peoples of Britain which took place as a result of the Industrial Revolution. In the eighteenth century, the most densely populated parts of Britain were in the south and east, with London and Bristol as the two most important centres. With the Industrial Revolution there were movements of people from the agricultural areas into the developing industrial areas, in most cases situated on the coal-fields. In the north these movements were largely associated with changing methods of manufacture consequent on the introduction of machinery. In South Wales some of the earliest changes in population were influenced as we have seen by the growth of metal industries, but later, especially during the second half of the nineteenth century, the more important increases in population resulted from the growth of the coal industry. In South Wales this was largely an industry dependent on export trade, and thus the increase in population in Glamorgan bears a definite relation to the expansion of the coal trade. For example, while in 1801 there were in that county less than 71,000 inhabitants, of whom less than 7,000 were engaged in all branches of mining and industry, in 1921 the population of the county was over a million, with more than 150,000 men engaged in mining alone. In the accompanying table it will also be noted that the counties which show the greatest increase in population are those with the greatest number of miners, the population of Monmouthshire being ten times as great as in 1801 and that of Glamorgan almost eighteen times as great.

	Population in 1801.	Population in 1921.	Number of Adult Males in 1921.		
			In Agriculture.	In Coal-mining.	Metal Workers.
Glamorgan	70,879	1,252,481	9,796	159,753	46,997
Monmouthshire	45,568	450,794	7,875	61,074	18,664
Carmarthenshire	67,317	175,073	10,698	14,244	9,459
Breconshire	31,633	61,222	4,810	6,209	1,059
Pembrokeshire	56,280	91,978	8,380	1,331	2,942

The enormous increase in the population of South Wale particularly that of Glamorgan, is only to be paralleled the most highly industrialized regions of Britain.

The Growth of Towns

These changes in the peoples of South Wales have affecte various areas at different times. Thus some towns during th nineteenth century have grown rapidly and have subsequentl been overshadowed by others which have expanded undu the influence of new industries or as a result of new facilitie The towns have grown at various rates and some of tho which were earliest to develop have long passed their zeni and declined ; in some cases, neighbouring towns have com peted with one another and the resulting conditions ha often been influenced as much by the foresight and personal ities of leading industrialists as by the more strictl geographical factors.

Pembrokeshire, despite the early development of its co trade, still remains essentially an agricultural region, an many of its towns have scarcely developed at all during th last hundred years. Tenby has grown as a seaside reso on account of its fine scenery and good sands, while Pembrok Dock grew owing to the building of the dockyard there.

In the more industrial part of South Wales one of th first towns to develop to a notable extent was Merth Tydfil, which grew at an early date for reasons which ha already been explained. By 1831 this town had a populatio equal to that of Cardiff, Swansea and Newport together, b its importance has declined, partly as a result of the chan in the location of the iron and steel industry and partly as result of the exhaustion of the easily mined coal seams of th area.

The relations of the chief ports during the same period a also very interesting. Newport and Swansea were for man years ahead of Cardiff, but this town overtook its neighbou and grew at an amazing rate during the later part of th century ; the population of Swansea grew steadily throughou the century, but that of Cardiff expanded much more slow until after 1851, a change that reflects the growth of co

export trade. But in the early part of the nineteenth century, although Cardiff was smaller than other Glamorgan towns, it was nevertheless regarded by many as the metropolis of South Wales.

	1801.	1821.	1841.	1861.	1881.	1901.	1921.
Cardiff .	1,870	3,521	10,077	32,954	82,761	164,333	200,184
Swansea .	6,831	11,236	19,115	33,972	50,120	94,537	157,554
Newport .	1,423	4,951	13,766	24,756	33,932	67,270	92,358
Merthyr .	7,705	17,404	34,977	49,794	48,861	69,228	80,116

The industrial towns in several cases grew at centres which had already been occupied by small towns, in some instances the largest towns in early South Wales—as at Newport, Cardiff, and Swansea. Thus those advantages of the site of Swansea, which determined its selection as a port in the Middle Ages, also favoured its subsequent growth. On the other hand, the sites of Neath and Carmarthen, while they were admirable for the ports of early times, were for varied reasons unsuitable for the development of great ports (figs. 15 and 17). The location of Cardiff and Newport at the crossings of the rivers was determined at a very early date, but the full advantages of these positions were only realized later when the development of transport routes along the valleys of the coal-field made them the foci of expanding industrial areas.

Cardiff is situated in a relatively flat area, being built largely on a gravel terrace (fig. 14), and the town has grown into an impressive and well-ordered city. The docks have been constructed on the alluvial areas to the south of the city and the main industrial development has taken place near them. There are, however, few works or factories which give rise to quantities of fumes or smoke, and the city is much cleaner than most of the industrial centres of northern England. For this reason, residential districts almost completely surround the city on the west, north and east. The extensive residential areas east and north-east of the city, on the gravel terrace and the higher ground behind it, represent a some-

what unusual feature, the residential areas in many citi being situated on the west.

The development of the site of Swansea has presente greater difficulties. The original settlement, south of t Tawe gorge, was on a narrow strip of low ground whi extends along the coast and in front of the Pennant San stone escarpment of Town Hill (fig. 15). The town h expanded mainly in three directions, northwards along t Tawe valley, and along the low ground to the east and we of the river. The greater number of the works are situated the north of the Pennant Sandstone escarpment. The doc have developed mostly to the east of the Tawe (fig. 28 while the residential areas extend mainly out to the we where they rise to a considerable height on the face of t escarpment and overlook the bay. On account of the pr vailing south-westerly winds they escape much of the smo and fumes associated with the industries.

Some of the early industrial towns, including Merth Tydfil, grew up around ancient settlements. But with t continued spread of industry towns sprang up where the had formerly been no habitations, and where the early co ditions had been unfavourable to settlement. This w especially so in the case of the towns which sprang up in t valleys of the east of the coal-field. These valleys are narr and steep-sided and many of them were marshy and u inhabited until the opening of mines brought into them va populations. These valleys are now among the most dense populated parts of Britain. The development of towns such an area is hampered by the physical features in a mann that does not occur in any other coal-field in Britain, for t physical characters of the coal-field and the nature of i valleys are largely determined by the Pennant Sandsto and such a massive sandstone is peculiar to the Coal Measu of South Wales. Thus there is no other part of Britain wi a comparable population in which the surface is so cut deep valleys.

Many South Wales towns are little more than strings villages, often miles in length, with no civic centre and wi few of the amenities of town life, for the form of the grou

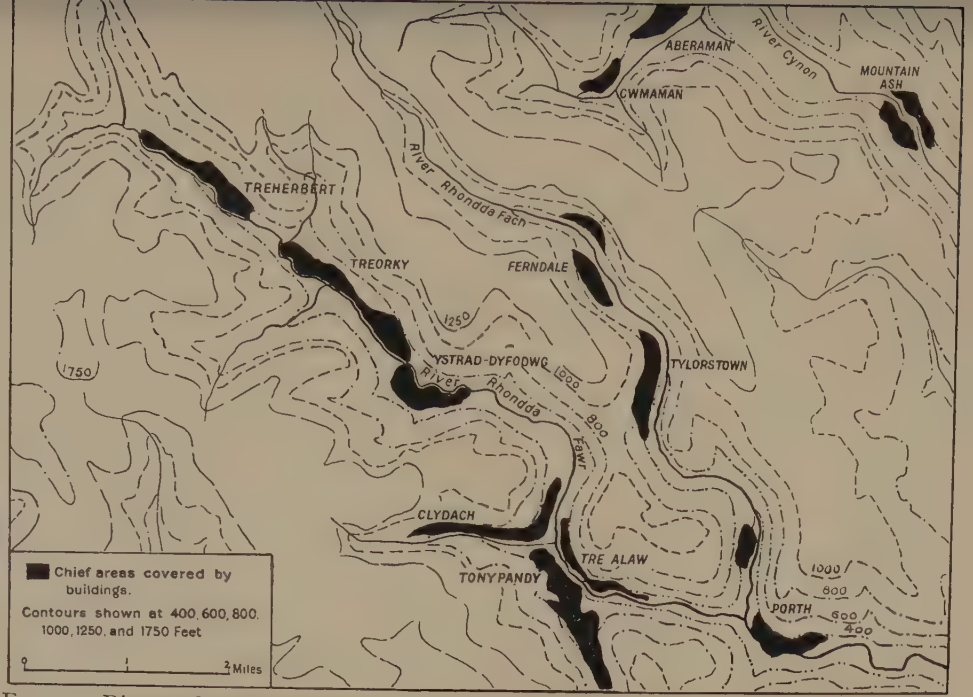


FIG. 33.—Diagram Map to show the Distribution of the Principal Towns in the Rhondda Valleys

makes it impossible to build towns of normal character with main routes radiating from a common centre (fig. 33). Consequently, most of the dwellings are arranged in monotonous terraces which run along the length of the valleys. Owing to the steep slopes of the sides and to the geological structure many of the valleys are particularly liable to landslips, which adds still further to the difficulties of building in some areas. Usually the least attractive towns are to be found in the valleys of those rivers which rise within the coal-field and which are *cul de sacs*, often only entered by roads from the south.

At the confluences of the valleys there has generally grown up a more important town; Pontypridd is perhaps one of the best examples of such a town. Where the valleys open out on the shales of the Upper and Lower Coal Series larger towns have also grown up, as at Caerphilly and Ammanford.

It may be remarked that the population in the coal-field valleys is much more dense than would appear to be the case from the figures given on the maps (figs. 30, 32), for in most cases the people are concentrated in the valleys, leaving the hills almost uninhabited, and they are not spread evenly over the parish. Thus in the Rhondda Urban District in 1911 there were 166,873 persons in 23,871 acres, that is, an average of 4,480 persons to a square mile, but it has been calculated that the area actually built on at that time was no more than 4,500 acres, giving an actual density of 23,680 persons to each inhabited square mile.

The growth of these coal-field towns has been very rapid. In the early part of the century, the areas which were developing were mainly in the east of the coal-field. The areas in mid-Glamorgan, which had meanwhile remained almost unchanged, later expanded very rapidly. The varying rates of expansion of areas in the different parts of the coal-field are illustrated by the figures given below; it will be noted that Gelligaer (in the east) increased early, the Rhondda valley somewhat later (especially after 1861), while Llandyfodwg (in mid-Glamorgan) actually showed decrease at some periods as its men moved to the areas which developed earlier.

Populations of some Coal-field Parishes

	1801.	1811.	1821.	1831.	1841.	1851.	1861.	1871.	1901.	1921.
Ystrad Dyfodwg (Rhondda)	542	973	985	1,047	1,363	1,998	3,035	16,914	113,735	162,717
Llandyfodwg	244	216	296	309	338	284	254	1,023	6,563	8,731
Gelligaer . .	1,051	1,022	1,247	1,825	3,215	3,807	5,778	9,193	17,242	43,121

The growth of large towns in South Wales created many new problems, of which we may note the importance of the supply of water for domestic and for industrial purposes. In many instances this need has been met by impounding the head-waters of the streams to the north of the coal-field, usually on the area of Old Red Sandstone, where the heavy rainfall gives an abundant supply, the water being conveyed by pipes from the reservoirs thus formed. Cardiff, Merthyr and Swansea derive the greater part of their water supply from such sources.

Population Changes in the Rural Areas

It will be apparent that the changes in population in the industrial areas have largely resulted from the immigration of people into those areas. A certain proportion of the changes may be accounted for by the natural increase of population, but clearly the greater part of the increase is due to a movement of population. In the early years of the Industrial Revolution in South Wales, the farmers and others who visited the iron manufacturing towns and the mining villages with country produce returned home with stories of the wonderful prosperity and high wages, and consequently the young people migrated from the adjoining rural areas. Thus we find in the early years of the nineteenth century that there was actually a decrease in the population of many rural parishes in the Vale of Glamorgan, in Gower, Brecon-shire and Carmarthenshire.

In later years this decline has been checked in some areas, the rural population in certain cases having increased slightly owing to the proximity of a dense population requiring rural produce.

POPULATIONS OF SOME RURAL PARISHES

	1801.	1811.	1821.	1831.	1841.	1851.	1921
St. Donats . . .	198	191	163	151	151	132	8
Cowbridge . . .	759	850	1,107	1,097	1,080	1,066	1,15
Reynoldston (Gower)	198	217	260	220	258	315	27
Senni (Brec.) . .	339	329	340	303	292	294	18
Glyntawe (Brec.) .	80	74	102	89	118	107	18
Llanstephan . . .	974	997	1,185	1,274	1,253	1,277	1,13

MIGRATION INTO SOUTH WALES

The extent of the migration from the areas near the coa field in the early part of the nineteenth century is shown the census of 1851, which records the county of birth of th people living in each area in South Wales. Thus of the 76,8 people living at that time in the Merthyr district the great proportion had been born in some part of Wales, but on 53 per cent of them in Glamorgan. Nearly 10,000 ha migrated from Carmarthenshire, about 3,000 each from th counties of Monmouthshire, Pembrokeshire and Cardiga shire, but less that one thousand from each of Gloucestershi and Somerset. Of the 35,000 people of 20 years old an upwards who were living in Merthyr Tydfil at that time, on 9,000 were born in the area (fig. 34).

In the Cardiff district at the same time, of a population 46,491, Somerset, Gloucestershire and Devonshire had contr buted a large proportion, while less than one thousand perso had migrated from Carmarthenshire and Pembrokeshire an only 450 from Cardiganshire. Thus even at that stage th people moving into the Cardiff area were predominant English. On the other hand, the Swansea district receive few people from England (except Devon and Cornwall) b greater numbers from Carmarthenshire.

Later immigrants into South Wales came partly from th same counties and partly from more distant places. Th opening of railway communications made it much less of a adventure to travel and settle in a far part of Britain, and 1911 the population of Cardiff included considerable numbe

from such areas as Lancashire and Durham. At that time about 35 per cent of the people of Glamorgan had been born in other counties; more than 13 per cent had come from other counties of Wales, and thus over 20 per cent had come from places outside Wales. Of the people living in Cardiff in

FIG. 34.—Map to illustrate the County of Birth of the People living in Merthyr Tydfil in 1851

Each dot indicates ten persons born in the county where the dot has been placed.

1911 about 30 per cent were born in England (including about 4 per cent from each of the neighbouring counties of Gloucestershire and Somerset); it must be remembered, however, that the children of the earlier immigrants, although born in Glamorgan, were really of English origin.

The immigrants in the first instances were mainly young men, and it was generally later that their friends and families followed them. It has always been a striking fact that while in Britain as a whole the number of males is less than the number of females, in the industrial areas of South Wales there is a marked deficiency of women. Thus in England and Wales as a whole, females outnumber males in the ratio of 1,095 to 1,000, whereas in Monmouthshire in 1921 the proportion was only 940 females to 1,000 males, in Glamorgan 964 per 1,000 and in Breconshire 995 per 1,000. In Carmarthenshire, on the other hand, females outnumber males in the ratio of 1,019 to 1,000.

It follows from what has been said that the people of South Wales include immigrants from many areas, and while the native Welsh people have contributed largely to the industrial population (the short dark type of Welshman being especially represented in the industrial areas), movements of people since the Industrial Revolution have tended still further to the production of a community of very mixed origins.

The Welsh Language

One result of these changes has been the gradual decline of Welsh as the language of the majority of the population. Before the Industrial Revolution, Welsh was the more important language over the greater part of the uplands of South Wales. At present, however, Welsh is not much spoken in the valleys of Monmouthshire, while in the Taff and Rhondda valleys Welsh is spoken by only about half the population.

Further west, in Carmarthenshire (for instance in the Gwendraeth valley, on the north-west of the coal-field), Welsh is the universal language. Welsh is also the usual language in north Pembrokeshire, but in south Pembrokeshire, as in Gower, English is predominant. The same is true of east Breconshire, a region which communicates freely with the English plain.

Interesting differences are also to be noted in the ports: compare, for instance, Cardiff, Swansea and Llanelly.

English and Welsh Languages (Persons aged 3 Years and Over)

	Speaking Welsh only.	Speaking both Languages.	Speaking English only.
	Per cent.	Per cent.	Per cent.
Cardiff	0·3	4·9	94·8
Swansea	1·7	27·4	70·9
Llanelly	2·2	69·8	28·0
Ebbw Vale	0·3	7·3	92·4
Rhondda	3·0	45·5	51·5
Ammanford	7·0	74·4	18·6

General Considerations

The changes and movements of population in South Wales in the last 150 years have been closely related to industrial developments, and may be regarded as comparable with the changes which have occurred in other industrial regions of Britain. In South Wales the most important changes resulted from the growth of the early iron and coal industries, both of which developed first in areas which had obvious geographical advantages at that time. Changes in the conditions affecting the iron industry, such as the increasing use of steel resulting from technical advances, and the consequent dependence on imported ore, at first produced no great changes in the location of the industry, which remained in the same centres despite geographical disadvantages—an example of industrial inertia which may be paralleled in many areas. But gradually these industries have moved towards the ports. Thus Merthyr Tydfil, formerly the centre of the iron trade, in 1921 had only just over 3,000 of its population engaged in metal works, while Swansea had 12,000 and Cardiff had over 8,000.

The coal industry in its development followed the lines of least resistance, mining gradually extending into the deeper parts of the basin and new towns have sprung up with each generation, while certain of the older towns have declined in importance if not in actual numbers.

So the conditions of South Wales at present show the results

of the inter-play of many factors, some of which are onl
indirectly connected with Wales ; the physical and geologic
structure of the area, the changing conditions brought abou
by progressive industrialization and scientific discovery, th
personal influences of the inhabitants and the varying stat
of world trade, all these have contributed to the presen
position of affairs. At certain times in the history of a
industry one or other of these factors may have dominate
the situation so that the others were temporarily unimportan
but changing circumstances have repeatedly led to ne
developments in new areas. In the history of South Wal
within the past century there have been several crises, som
of which have determined or initiated new tendencies i
industry. It appears that at the present time South Wal
is again passing through such a crisis, and it must for som
years be uncertain whether the industries will continue t
develop along the lines followed hitherto, or whether a radic
re-adjustment to new conditions is impending. It is thu
difficult to write of the probabilities of the future, but wha
ever changes may occur, it must be realized that the presen
conditions, the result of all that has happened in the pas
will to a great extent determine the movements of the futur

A GLOSSARY OF SOME GEOLOGICAL AND PHYSICAL TERMS

Alluvium.—Sediment laid down by rivers, chiefly in the lower parts of their courses. Consists usually of sands and gravels, giving a fertile soil ; usually occurs in that part of a valley which is liable to be flooded.

Anticline.—A fold in sedimentary rocks, in which the beds have been arched upwards. An anticline may be only a few feet or many miles across. Denudation generally has removed the top of the fold so that older rocks occur at the surface in the centre (see fig. 3).

Boulder Clay.—A deposit left by glaciers or ice-sheets. It consists of large and small boulders, pebbles and clay, thus differing from a water-laid deposit in which the sediments are sorted or graded into pebble beds, sands and muds. Boulder clay is also different from water-laid deposits in its lack of stratification. Occurs as a superficial deposit in many parts of Britain north of the Thames and Bristol Channel.

Brachiopod.—An invertebrate animal, with a shell which consists of two unequal parts, joined together along a hinge. Formerly very abundant, they are now represented less commonly in modern seas by the lamp-shell.

Breccia.—A variety of conglomerate, in which the included pebbles are angular, not having been water-worn, as is the case in a conglomerate. This may result from the fragments in a breccia having been carried only a short distance from their source.

Chalk.—A soft white limestone of marine origin. Occurs in the North and South Downs and in the Chilterns.

Conglomerate.—A ' pudding-stone ', usually consisting of sandstone with rounded pebbles scattered through it. It is a coarse sedimentary rock deposited in water by powerful streams or currents.

Consequent Streams.—Streams or rivers which began to flow immediately after the elevation of a portion of the sea floor to form new land ; the direction of the rivers was determined by

the inclination of the elevated tract and usually coincides with th dip of the rocks in the area. Naturally, consequent stream generally represent the most ancient drainage in an area.

Corals.—Invertebrate animals which secrete a skeleton c calcium carbonate. Now found living in the seas near th Equator, but formerly common in Europe. Fossil corals ar abundant in many Palæozoic limestones.

Denudation.—The wearing away of the rocks, whether by th work of the atmosphere, rain, rivers, frost, ice or sea.

Dip.—The inclination of a band or bed of rock to the hor zontal. Dip is measured as the number of degrees at which th bed is inclined or as the distance through which it falls in a give horizontal distance ; *e.g.*, a coal seam dipping at 15 degrees fall at the rate of just over 9 inches in a yard.

Drift.—A term applied to those superficial deposits whic have resulted from the action of ice. Includes boulder clay moraines, gravels, etc.

Drowned Valley.—A narrow inlet of the sea which has resulte from the flooding of the lower parts of a valley, owing either t the sinking of the land or to the rising of sea-level—*e.g.*, Milfor Haven.

Escarpment.—A long ridge of hills formed by the outcro of a belt of hard rocks. On one side the ridge slopes gently i the direction of the dip of the rocks ; on the other side (the scar side), the ridge is usually much steeper—*e.g.*, the Black Moun tains of Carmarthenshire.

Fault.—A fracture or dislocation in the earth's crust alon which movement has taken place. Generally the rocks of on side have slipped down the fault plane.

Fireclay.—A variety of clay which by reason of its deficienc in alkalies (potash and soda) is relatively infusible. In man Coal Measure fireclays, which underlie coal seams, are numerou roots of the trees which formed the coal. The fireclay is thu an ancient soil, from which it is believed that the growing tree removed the alkalies.

Flagstones.—Sandstones which are evenly bedded and whic can readily be split into thin sheets suitable for paving, etc.

Flint.—An impure form of silica (quartz) which occurs i irregular lumps or nodules in the chalk. Black, brown, or almos white in colour.

Grit.—A sandstone, often of coarse texture, with particle which are sharp and angular.

Hæmatite.—Red oxide of iron (Fe_2O_3) ; a rich iron-ore

sometimes called Kidney Iron-ore, from the form it frequently assumes.

Igneous rock.—A rock formed by the solidification of fused or molten material. If molten lava is poured out at the surface and solidifies there, a volcanic rock results; many igneous rocks, however, have solidified at great depths in the earth's crust, and have been exposed at the surface by the denudation of the rocks which formerly covered them. Examples of igneous rocks are basalt and obsidian (volcanic rocks), granite, porphyry, etc.

Lava.—Molten material poured out at the surface by a volcano. The term lava is also applied to the igneous rock formed when the molten matter solidifies.

Limestone.—A general term for all rocks which are mainly composed of calcium carbonate (carbonate of 'lime'). Most limestones have been formed in the sea, but some in fresh-water lakes. Chiefly made up of shells, corals or other skeletons of aquatic animals.

Littoral deposits.—Deposits which have been formed near a shore line. They are generally coarse, including conglomerates or pebble beds.

Marl.—A calcareous (or 'limey') clay. Frequently gives a less heavy soil than a true clay.

Mature river.—A river which has worn down its bed until its gradient is very gentle, so that it meanders along a wide valley; *e.g.*, the River Towy.

Meanders.—The curves in the course of a river when it has nearly completed the vertical cutting of its valley and its gradient is only sufficient to enable it to carry its load. It widens its valley as it swings in curves or meanders whose size depends on the volume of the stream.

Moraine.—Ice-borne material, usually consisting of boulders and pebbles of all sizes and often of irregular shapes.

Outcrop.—The area where a bed or series of beds of rock comes to the surface. The form and breadth of the outcrop depend on the thickness of the bed, the angle of dip and the form of the ground.

Quartz.—A hard crystalline mineral, occurring in hexagonal prisms, composed of silica. Forms an important constituent of granite and (as sand grains) the chief constituent of sandstones.

Quartzite.—A sandstone composed almost entirely of quartz grains which are held together by a deposit of silica which fills the spaces between the grains. The rock is therefore almost pure silica.

Raised beach.—A terrace or platform above high-water mark,

often bearing shells and other beach material, and proving tha the land has risen or the sea receded.

River Terrace.—A level tract, usually covered by gravel situated at a higher level than the present alluvial plain of river. It represents a former alluvial plain through which th river has cut a new channel owing to an increase in its gradien See figs. 14 and 15, illustrating examples at Cardiff and Neatl

Sandstone.—A rock composed mainly of quartz grains, hel together by some form of natural cement which has been deposite in the spaces between the grains.

Scarp.—The steep slope of an escarpment—*e.g.*, the northern face of the Black Mountains (fig. 7).

Sedimentary rock.—A rock which has been deposited as sediment. It was formerly thought that all sedimentary rock had been deposited in water, and they were sometimes known a aqueous rocks. It is now recognized that a small proportio of sedimentary rocks have been deposited on the land, as by win action. The sedimentary rocks include sandstones, limestone and clays.

Shale.—A laminated clay, which is readily split along it bedding planes.

Slate.—An altered clay-rock (such as clay or shale) which a a result of intense pressure will now split or cleave along plane which do not necessarily coincide with the bedding planes. Mos frequent in the Lower Palæozoic rocks.

Strike.—The strike of rocks is at right angles to the directio of greatest dip. The outcrop coincides with the general direc tion of the strike. Thus a river flowing with the strike (usuall a subsequent stream) keeps on the same group of rocks throughou its course (*e.g.*, the rivers Amman and Gwendraeth).

Submerged forest.—An ancient forest surface, with roo of trees in the position of growth, below high-tide mark. Give evidence of recent sinking of the land (or of the rising of sea-level A good example occurs near Black Pill, Swansea.

Superimposed drainage.—A drainage system which ha been developed on a series of rocks, usually simple in structur through which the rivers have cut their way to the underlyin rocks. These latter may have a more complicated structure, bu the rivers tend for some time to persist in their original course so that the drainage is superimposed on rocks having a structur to which the river system appears to bear no relation. See fig. 9

Syncline.—A down-fold in sedimentary rocks. In a synclin the newer rocks occur in the centre. See fig. 3 *c*, etc.

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Maps

The most useful maps for the reader desiring a somewhat fuller acquaintance with the topography of the district are the half-inch to the mile ' layered ' maps ; sheet 26 (Swansea) and sheet 27 (Newport) cover most of the area.

Sheet Number 7 of a similar map on the scale of a quarter-inch to a mile also covers most of the area, but Cardiff is situated outside the sheet. For a more detailed map of the area the various sheets of the one-inch to the mile ' Popular ' map of the Ordnance Survey are strongly recommended.

A useful geological map is the quarter-inch ' index ' map. Sheet 14 includes the northern part of the coal-field and much of Central Wales, while sheet 18 covers the south of the coal-field and the Bristol Channel. The one-inch maps of the Geological Survey cover the whole of the coal-field and the coastal lowlands in fourteen sheets ; these maps may be obtained in ' solid ' or ' drift ' editions. Geological maps of the coal-field on the scale of six inches to a mile are also published.

A booklet by Dr. F. J. North entitled *Geological Maps of Wales*, issued by the National Museum of Wales, gives a complete list of all published geological maps, and much other information.

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